STATE OF CALIFORNIA
The Resources Agency

Department of Water Resources

BULLETIN No. 169

SOUTHERN TUOLUMNE COUNTY
WATER RESOURCES DEVELOPMENT

JULY 1968

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

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FOREWORD

Bulletin No. 169, "Southern Tuolumne County Water Resources Development", presents a plan for development of the water resources of Southern Tuolumne County. The plan as presented includes a small reservoir at the Shanahan Flat site about five miles east of Groveland, and another reservoir at Stone Meadow about two miles south of Mather. Provisions would be made to supply domestic water from these reservoirs as well as provide recreation and fishery enhancement.

A previous reconnaissance investigation of the water resources of Southern Tuolumne County was conducted by the Department during the 1958-59 and 1959-60 fiscal years. The results of the investigation were presented in the preliminary edition of Bulletin No. 96, "Southern Tuolumne County Investigation". The project presented in Bulletin No. 96, (Harden Project) to develop the water resources of Southern Tuolumne County was largely dependent on the marketing of hydroelectric energy for the repayment of reimbursable project costs. Since the time the project was formulated, technological advances in the production of thermal power have caused power values to decrease; furthermore, hydroelectric plant construction costs have increased. These unforeseen economic developments have rendered the power function of the (Bulletin No. 96) project economically unjustified.

A public hearing on the preliminary edition of Bulletin No. 96 "Southern Tuolumne County Investigation, March 1965" was held in Groveland on March 24, 1966. Subsequently the Tuolumne County Board of Supervisors expressed the opinion that rather than expend additional money to prepare a final edition of Bulletin No. 96, any available funds should be spent toward investigation of a project which could be implemented by local interests to develop the water resources of Southern Tuolumne County.

The 1966 Legislature appropriated $30,000 to the Department of Water Resources for a new study to derive a modified project which would develop the water resources of Southern Tuolumne County. This legislation was initiated by local interests in Tuolumne County. The results of this study are contained in Bulletin No. 169.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
June 28, 1968

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DEPARTMENT OF WATER RESOURCES

RONALD REAGAN, Governor
WILLIAM R. GIANELLI, Director, Department of Water Resources
JOHN R. TEERINK, Deputy Director

SAN JOAQUIN DISTRICT

Carl L. Stetson . . . . District Engineer

Richard W. Meffley . . . . .Chief, Special Investigations Section

Technical studies were conducted and
the bulletin was prepared under the supervision of

Sam L. Stringfield . . . . Senior Engineer, W.R.

by

W. Max Hubbart . . . . Associate Engineer, W.R.

Charles L. Batchelor . . . . Assistant Civil Engineer

Special services were provided by

Anthony I. Ramuglia . . . . Senior Economic Analyst
Richard L. Campbell . . . . Assistant Economic Analyst
Thomas I. Iwamura . . . . .Associate Engineering Geologist
Richard Laursen1/ . . . . Recreation Planner II
Fred Meyer2/. Fisheries Biologist III
William R. Powell . . . . Associate Land Agent

1/ Employee of Department of Parks and Recreation
2/ Employee of Department of Fish and Game

CALIFORNIA WATER COMMISSION

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WILLIAM P. MOSES, San Pablo

NORRIS POULSON, La Jolla

MARION R. WALKER, Ventura

-- 0 --

WILLIAM M. CARAH
Executive Secretary

HERBERT W. GREYDANUS
Engineer

ACKNOWLEDGMENT

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Forest Service, United States Department of Agriculture

Geological Survey, United States Department of the Interior

California State Department of Parks and Recreation

California State Department of Fish and Game

County of Tuolumne

ABSTRACT

BULLETIN NO. 169
SOUTHERN TUOLUMNE COUNTY WATER RESOURCES DEVELOPMENT

The Southern Tuolumne County study area, about 100 miles directly east of San Francisco, encompasses 270 square miles of foothill and mountainous terrain. It is within the drainage basin of the Tuolumne River on the westerly slopes of the Sierra Nevada due west of Yosemite National Park.

Runoff from snowmelt and rainfall constitutes the only significant water resource that can be developed within the area. The runoff from this drainage basin has been extensively developed for use in the San Francisco Bay Area and the San Joaquin Valley. Local development and use of runoff has been very minor.

The economy and growth of the area has been retarded by the lack of development of its recreation potential. Presently the only water-associated recreation activities occur at a few accessible stream sites, thus the variety of recreation opportunities is severely limited.

The Stone Meadow and Shanahan Flat projects, proposed in this report, were selected as being superior to others considered. The proposed Stone Meadow Reservoir would be located on an unnamed tributary to the Middle Fork of the Tuolumne River about two miles south of Mather at an elevation of 4,520 feet. The proposed Shanahan Flat Reservoir would be located on Big Creek about one mile west of Smith Station at an elevation of 2,950 feet. The projects would include recreation facilities to accommodate an ultimate annual use of 641,000 visitor-days, and would also provide the domestic water demand until the year 2025.

CHAPTER I. SUMMARY AND RECOMMENDATIONS

The economy of Southern Tuolumne County would be enhanced by a water development project that would provide recreation, fishery enhancement, and a domestic water supply. The basic objective of this investigation was to formulate such a project. A plan is presented for two projects that would meet the domestic water requirements of the Southern Tuolumne County Area for the foreseeable future and provide fishery enhancement and recreation benefits. A more detailed study will be required to demonstrate the feasibility of these proposals.

Summary

Southern Tuolumne County study area is located on the westerly slopes of the Central Sierra Nevada immediately west of Yosemite National Park and about 100 miles directly east of San Francisco. Elevations range from 300 feet above sea level to a maximum of about 6,000 feet. Precipitation varies from 18 inches in the lower foothill area to 55 inches in the higher portion of the area to the east. Precipitation during October through April is mainly in the form of snowfall above elevation 3,500 feet.

The central area of Southern Tuolumne County from Big Oak Flat to Groveland Ranger Station has moderate summers and cool winters. Summertime maximum temperatures are from 5 to 10 degrees Fahrenheit cooler than in the foothill and valley floor areas. Minimum temperatures at night are much cooler. Much of this area is covered by coniferous forest and is privately owned. Most of the residential development in Southern Tuolumne County is expected to occur in this area because of the natural beauty and the absence of climatic extremes.

Surface runoff of the Tuolumne River system constitutes the only significant source of dependable water supply available within the area. Water originating in the area has been developed extensively for use in the San Joaquin Valley and the San Francisco Bay Area. The Groveland Community Services District constructed facilities to obtain its water supply from the Hetch Hetchy Project in 1965. All other areas in Southern Tuolumne County presently use ground water for domestic supply.

The economy of Southern Tuolumne County is based mainly on recreation, livestock and poultry production, lumbering, and the operation of maintenance stations (the California Division of Highways, California Division of Forestry, United States Forest Service, and the Hetch Hetchy water supply system of the City and County of San Francisco).

Water-associated recreation in Southern Tuolumne County is very minor, being confined to a few accessible areas near streams. The lack of recreation reservoirs severely limits the variety of outdoor recreation opportunities. Access to the area via Highway 120, an all-year highway to Yosemite National Park, is excellent. The area is scenic, the climate is suitable for recreation, and additional camping facilities would assist in alleviating present overcrowded conditions in Yosemite National Park.

The principal area within Southern Tuolumne County which could use a domestic water supply is the proposed project service area along Highway 120 between Big Oak Flat and the Tuolumne-Mariposa County line near Buck Meadows. The demand for domestic water in the service area is estimated to increase from 150 acre-feet in 1975 to 1,890 acre-feet in 2025.

During this study, many alternatives were considered in the formulation of plans to develop the water resources of Southern Tuolumne County. The recreation potentials of four reservoir sites studied were found to rank qualitatively in the following order: (1) Stone Meadow, (2) Burch Meadow, (3) Shanahan Flat, and (4) Groveland. The Shanahan Flat site was found superior to the others from the standpoint of providing an economic domestic water supply. From the alternatives, a plan was evolved for local development which would include the purposes of recreation, fish enhancement, and conservation for domestic water supply.

The plan which was evolved includes the Stone Meadow and Shanahan Flat Projects, which would meet the year 2025 domestic water requirements and provide facilities for an annual use of 641,000 visitor-days by recreationists. The Stone Meadow Reservoir would be located on an unnamed tributary to the Middle Fork of the Tuolumne River about two miles south of Mather. The capacity at a normal pool elevation of 4,520 feet would be 8,500 acre-feet, and the water surface area would be 231 acres. The Shanahan Flat Reservoir would be on Big Creek about one mile west of Smith Station. The capacity at a normal pool elevation of 2,950 feet would be 3,920 acre-feet, and the water surface area would be 129 acres.

The domestic water supply for the service area would initially be provided from the proposed Shanahan Flat Reservoir. After about the year 2005 when the annual water requirements exceeded 650 acre-feet a supplemental supply would be released from Stone Meadow Reservoir, diverted from the Middle Fork by pipeline to a turbine-pump unit from whence the pump side of the unit would force a portion of the water through a pipeline which would extend a distance of about 5 miles along the old alignment of the Golden Rock Ditch to Big Creek above Shanahan Flat Reservoir. A pipeline would convey water from Shanahan Flat Reservoir to water treatment facilities, and thence the domestic water supply would be pumped throughout the service area.

The capital costs of initial project facilities are estimated to be as follows:

Item	Shanahan Flat	Stone Meadow
Dam and Reservoir	$1,398,700	$2,030,000
Recreation Facilities	482,000	992,000
Water Treatment Facilities	51,100	---
Water Conveyance to Service Area	214,700	---
Mather Diversion and Pipeline	---	149,300
Total	$2,146,500	$3,171,300

A summary of the present worths of all costs and benefits throughout the 50-year period of project analysis follows. No attempt was made to allocate costs and benefits between the projects for providing the supplemental water requirements after year 2005 and for making accretion releases from Stone Meadow Reservoir. The benefit-cost ratio for the total development is indicated to be 1.49 to 1.

Item	Shanahan Flat	Stone Meadow	Totals
Costs	$4,951,000	$8,085,400	$13,036,400
Benefits			
Recreation	5,512,000	12,100,000	17,612,000
Fish Enhancement	125,000	520,000	645,000
Domestic Water	1,138,700	---	1,138,700
Total	$6,775,700	$12,620,000	$19,395,700
Benefit-Cost Ratio			1.49:1

Recommendations

As a result of the findings of this investigation it is recommended that:

1. Tuolumne County use Bulletin No. 169 as a guide for future water projects in Southern Tuolumne County.

2. A local agency or agencies, when willing and able to undertake the necessary local financial obligations, consider proceeding with feasibility studies leading to possible project construction; further study by the State itself is neither necessary nor justified.

CHAPTER II. RESOURCES AND PRESENT DEVELOPMENT

Tuolumne County was organized in 1850. Subsequently, in April 1854, Stanislaus County was created from a portion of the original area of Tuolumne County. The major impetus for development of the Tuolumne area occurred when gold was discovered at New Jamestown in 1848 and in Columbia in 1850. As a result of gold mining activities several communities were established and the population of the County increased to 16,000 by the year 1860.

Projects to convey water to the mining operations and communities accompanied the early growth of the area. Remnants of some of these systems are in evidence today. Of particular historical interest is the Golden Rock Ditch in Southern Tuolumne County. It was built in the late 1850's by Chinese laborers using picks and shovels. Water which was diverted into the ditch by a diversion dam at Harden Flat was conveyed westerly along the northern slopes of Pilot Ridge, through Buck Meadows and Garrotte Basin to Big Oak Flat. The length of the main ditch and its distributaries totaled over 100 miles. The capacity of the ditch at the headworks has been estimated at 3,000 miner's inches (75 cubic feet per second). The ditch, flumes, and tunnel were a prodigious construction feat for that time. The ditch was periodically in operation to the year 1923 when it was abandoned. Although now overgrown by trees and brush, the ditch alignment can easily be traced except where it is obliterated by road construction.

Recreation is the most important aspect of the present economy of Southern Tuolumne County. A considerable amount of tourist trade is associated with travel to and from Yosemite National Park. A number of organizational camps provide a major portion of the recreation opportunities. Public camp sites in Stanislaus National Forest are of considerable importance to the recreation use of the area.

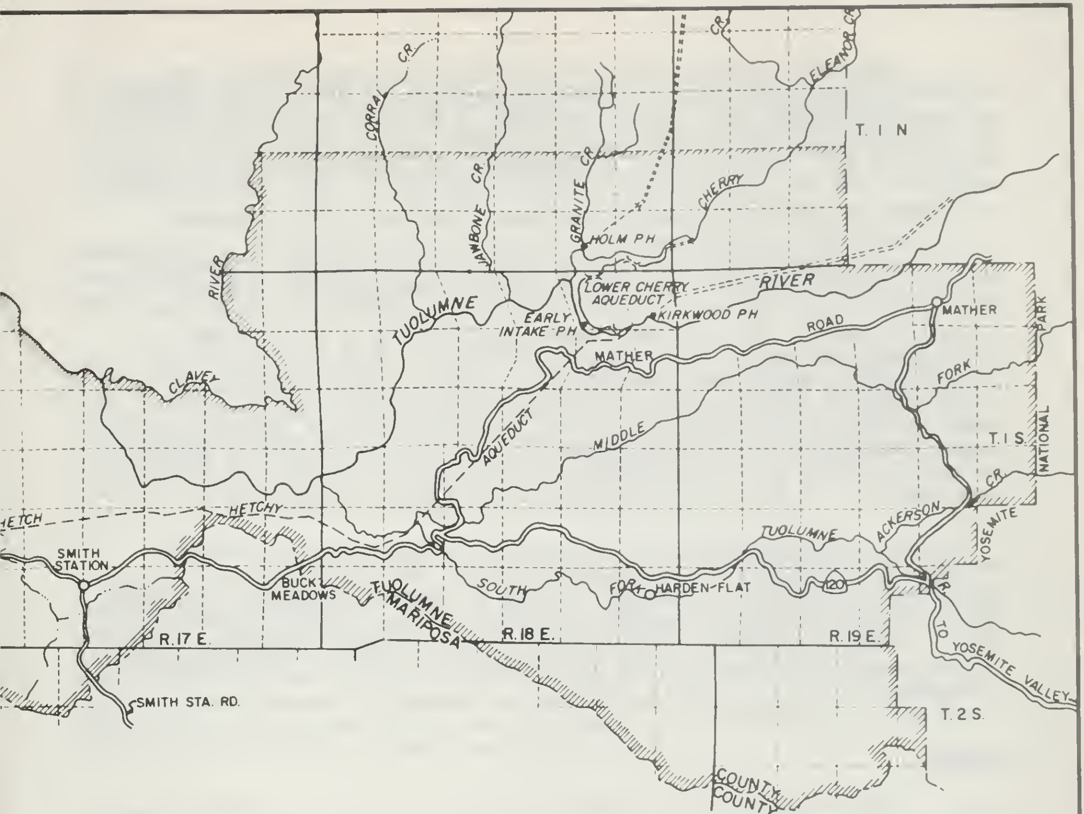
In addition to recreation, the economy of the area is based on livestock and poultry production and the operation of maintenance stations (California Division of Highways, California Division of Forestry, United States Forest Service, and the Hetch Hetchy water supply system of the City and County of San Francisco).

Natural Features

Location and Terrain

The Southern Tuolumne County study area is about 100 miles directly east of the City of San Francisco in a foothill and mountainous area of the western slopes of the Central Sierra Nevada. The study area, 270 square miles in extent, is bounded on the south by Mariposa County, on the west and north by the deeply entrenched Tuolumne and Clavey Rivers, and on the east by Yosemite National Park. The area of investigation is delineated on Plate 1.


T.1 S.
RIVER
R.14 E.
MT. DIABLO
B. & M.
R.15 E.
R. 16 E.
GROVELAND
BIG OAK FLAT
BIG
CREEK
HETCH
MOCCASIN
120
MOCCASIN
P.H.
MOCCASIN
PRIEST FOREBAY
CREEK
CREEK
HATCH
49
T.2 S.
DON PEDRO
RES.
COUNTY
OON PEDRO P.H.
TUOLUMNE
LA GRANGE RES.
132
MARIPOSA
COUNTY
T.3 S.
MODESTO
CANAL
LA GRANGE
TURLOCK
CANAL
DAWSON LAKE
TUOLUMNE
CO.
CO.
STANISLAUS
MERCED



LEGEND

BOUNDARY OF SOUTHERN TUOLUMNE COUNTY INVESTIGATION

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN DISTRICT

SOUTHERN TUOLUMNE COUNTY WATER RESOURCES DEVELOPMENT

AREA OF INVESTIGATION

1967

SCALE OF MILES

2 0 2 4

Elevations range from about 300 feet above sea level in the extreme southwestern part to a maximum of about 6,000 feet at the boundary of Yosemite National Park. The topography in the portion west of Big Oak Flat is generally one of precipitous hillsides and arroyos. Because of the shallow soil cover and hot, dry summers, the vegetative cover in this portion of the area consists principally of rangeland, brush, and scattered oak trees. A rather sharp contrast occurs from Big Oak Flat eastward.

In the central portion of Southern Tuolumne County between Big Oak Flat and Buck Meadows, an area of about 70 square miles, land elevations range from 2,500 to 3,500 feet. The topography may be considered as having moderate relief except in the relatively flat meadow lands. Several small ephemeral streams drain the area. A deeper soil cover and greater precipitation have resulted in a vegetative cover of moderate to dense stands of coniferous forest intermingled with oak and incense cedar, as well as rangeland and meadows. Most of the land is privately owned. Because of the attractiveness of the area, the absence of climatic extremes, and the private ownership of lands, most of the residential development in Southern Tuolumne County is expected to occur here.

In the eastern portion of Southern Tuolumne County from Buck Meadows to the Yosemite National Park Boundary, the topography is of relatively steep relief. Most of the area is covered by moderate to dense stands of coniferous forest, much of which is mature timber of commercial value. Future development in this area, which is almost entirely in public ownership, will be primarily for recreation, with lumbering of secondary importance.

Streams

The Southern Tuolumne County study area lies within the Tuolumne River Basin. Runoff from the area flows directly into four main stream systems. These are the Main Stem, Middle and South Forks of the Tuolumne River and Big Creek. The Main Stem of the Tuolumne River above its confluence with the South Fork drains an area of 770 square miles, most of which lies outside the area of investigation. The Middle and South Forks together drain an area of about 150 square miles in the eastern portion of the area of investigation and in Yosemite National Park. Most of the runoff of the Main Stem, Middle and South Forks is produced from snowmelt because of the high elevation drainage areas.

Big Creek, a tributary to the Main Stem of the Tuolumne River about four miles north of Groveland, has a drainage area of 25 square miles above the gaging station near Groveland. The drainage basin, which lies in the central portion of the area of investigation, ranges in elevation from about 2,500 to 3,800 feet; consequently, almost all the runoff is produced from rainfall.

Geology

Southern Tuolumne County is situated on the gently dipping westward slope of the Sierra Nevada geomorphic province. This province is approximately 430 miles long and varies from 40 to 80 miles in width. It has been described as an immense tilted fault block, which ranges in elevation from near sea level along its western edge to a maximum height of 14,496 feet at Mount Whitney. In cross section, the Sierra Nevada has a gentle westward slope and an abrupt eastern scarp.

Two subdivisions of the Sierra Nevada geomorphic province are represented in the investigational area: (1) a low-elevation or foothill province largely composed of metamorphic rocks, and (2) the High Sierra province, principally composed of granitic rocks.

The foothill province includes the western three-quarters of the area. Here metamorphic rocks form a relatively broad northwest-trending belt of tight folds. Locally, Mesozoic igneous rocks intruded these folds. The folds are capped locally by mid- and late-Tertiary volcanic rocks. A northwest-trending foothill fault system cuts through the foothills. The fault system varies in width from less than one mile to over three miles along its 120-mile length. Quartz veins and the Mother Lode mineral deposits are associated with this fault system.

The Sierra Nevada geomorphic province covers the eastern quarter of the area. It is underlain primarily by the granitic intrusive complex and some small remnants of older metamorphic rocks which occur as "roof pendants". Tertiary volcanic rocks locally blanket the bedrock complex. During the Pleistocene epoch, snow and ice accumulated in the higher mountains and formed many slow-moving glaciers. These glaciers greatly modified the topography by depositing moraines and by cutting huge U-shaped valleys such as Yosemite Valley. Several small glaciers still exist in the high mountain area east of Yosemite Valley.

Climate

The climate within Southern Tuolumne County varies with location. An orographic effect causes the mean annual precipitation to vary from about 18 inches in the lower foothill areas to 34 inches in the Groveland area, and to about 55 inches in the higher portion to the east. Practically all precipitation occurs during the period October through April.

The foothills in the western portion of the area have hot, dry summers and mild winters. In the central portion of the area, with elevations from 2,500 to 3,500 feet, summertime maximum temperatures are 5 to 10 degrees Fahrenheit cooler than in the foothills area and valley floor. This area is free of the annoying winter fogs that prevail in the San Joaquin Valley each year for several weeks.

In the eastern portion of Southern Tuolumne County, summertime maximum temperatures are even lower thereby enhancing the recreation aspects of the area. Freezing weather is common during the winter with a snowpack accumulating at the higher elevations.

Soils

The soils of Southern Tuolumne County can be divided into two broad categories: recent alluvial soils and upland soils. The alluvial soils are small in areal extent, being confined to streambeds and meadows. Upland soils were formed in place by the weathering and decomposition of the underlying rock material. These soils are important because they cover almost the entire area of investigation. The upland soils generally become deeper in profile and less rocky as elevation and precipitation increase. Shallow soil profiles and extreme rockiness, for example, are found in the lower western portions of the area, while deep and nearly rock-free soils are found in some of the more eastern portions of the area.

Sources of Water

The water resources of Southern Tuolumne County originate as direct precipitation in the form of rain or snow on the lands within the area. Over half this supply is used consumptively by evapotranspiration from forest, meadows, and rangeland within the area, and the remainder of it drains from the area by way of the Tuolumne River and the Hetch Hetchy Aqueduct.

Melting snow from the mountainous parts of the area provides the major portion of the annual runoff, which occurs mainly in the late spring and early summer. By late summer, the streams have reached annual minimums and are sustained by springs and effluent seepage.

A minor portion of the annual runoff is from small, ephemeral streams in the central and western portion of Southern Tuolumne County. Almost all of the runoff from this source is direct runoff from rainfall, with minor amounts being produced by effluent seepage to the streams.

Precipitation

Precipitation in Tuolumne County varies between wide limits from year to year and increases gradually from west to east with an increase in land elevations. Winter storms deposit relatively small amounts of precipitation in crossing the floor of the San Joaquin Valley. The amount of precipitation increases sharply, however, as the storms move toward and into the Sierra Nevada. Precipitation below an elevation of about 3,500 feet generally occurs in the form of rain; above this elevation most precipitation occurs as snow. A maximum mean annual rate of precipitation of about 55 inches occurs along the intermittently defined first crest of the Sierra. Between this area and the main crest, the precipitation is not noticeably affected by elevation. Here the average annual rate varies between about 45 and 60 inches.

Precipitation Stations and Records. There are 13 precipitation stations in or adjacent to the Southern Tuolumne area with sufficient length of record to be used for hydrologic estimates. These stations are not well distributed areally in that there are no stations above an elevation of 4,700 feet to give representative values for precipitation at higher elevations. The longest record of precipitation in Tuolumne County is that of the Sonora station which has a continuous record since the precipitation year of 1887-88. The precipitation year is from July 1 through June 30 of the following year. The longest continuous precipitation record in Southern Tuolumne County, at Hetch Hetchy Reservoir, extends from 1910 to the present.

Twenty snow courses in the Tuolumne River Basin are measured and maintained as part of the California Cooperative Snow Surveys. All of these courses are at or above an elevation of 6,500 feet. Measurements at these courses provide data which are used to forecast snowmelt runoff and thereby greatly increase the efficiency of operation of reservoirs in the area.

None of the snow courses are within the area of investigation. Information on the location and measured April 1 water content at the snow courses is presented in the Department of Water Resources Bulletin 120 series, "Water Conditions in California".

The records of precipitation at most stations and snow courses in or near Southern Tuolumne County have been published in reports of the United States Weather Bureau and the Department of Water Resources. The elevations, periods and sources of record, and mean, maximum, and minimum annual precipitation for the precipitation stations are listed in Table 1[1/]. In those instances when it was found necessary, precipitation records were extended to cover the 50-year mean period from 1915 to 1965 by direct correlation with records of nearby stations covering that period. Plate 2, entitled "Lines of Equal Mean Annual Precipitation", shows the locations of selected precipitation stations and the lines of equal mean annual precipitation.

The annual precipitation recorded at the Groveland station has varied from about 60 percent to about 170 percent of the mean. The maximum annual precipitation of record at this station, in 1937-38, was 57.64 inches. The minimum precipitation of record in 1960-61, was 20.59 inches. Approximately 67 percent of the yearly precipitation at Groveland occurs during the period December through March; less than 4 percent occurs from June through September.

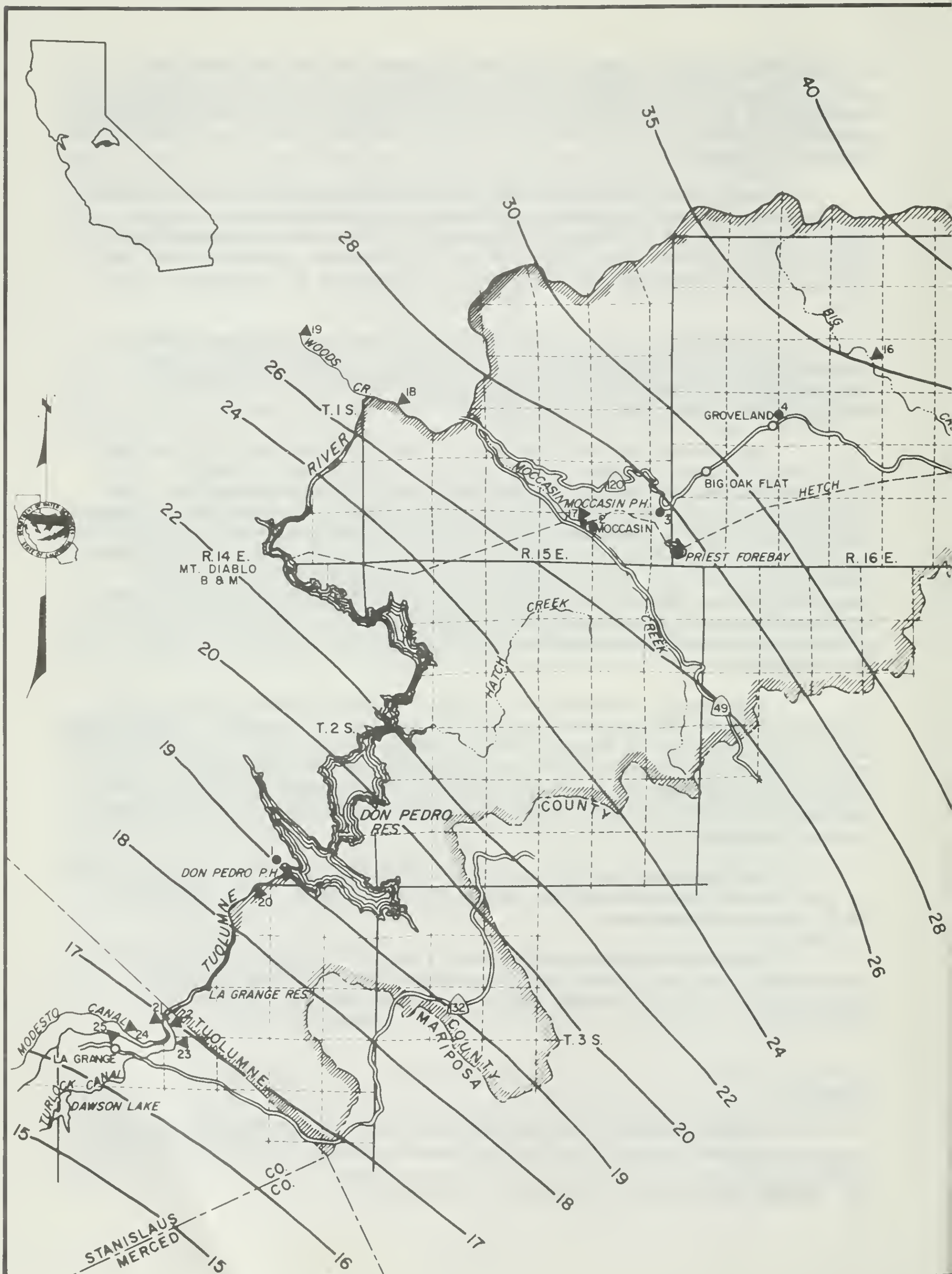
The maximum recorded snowpack in the Tuolumne River Basin occurred at the Spotted Fawn snow survey course in 1952, when a water content of 82.5 inches was measured.

Because no single precipitation station is representative of the entire area, the stations at Don Pedro Reservoir, Groveland, and Lake Eleanor were selected to show annual amounts of precipitation. Annual precipitation recorded at these stations is presented in Table 2.

Runoff

Surface runoff from the Tuolumne River system constitutes the only significant source of developable water supply available to Southern

1/ Tables are placed at the end of the chapter.



R. 14 E.
MT. DIABLO
B & M
R. 15 E.
R. 16 E.
T. 1 S.
T. 2 S.
T. 3 S.
WOODS CR.
RIVER
TUOLUMNE
MOCCASIN
CREEK
MOCCASIN P.H.
MOCCASIN
GROVELAND
BIG OAK FLAT
HETCH
PRIEST FOREBAY
BIG
HATCH
CREEK
DON PEDRO RES.
DON PEDRO P.H.
COUNTY
LA GRANGE RES.
MARIPOSA COUNTY
TUOLUMNE
MODESTO CANAL
LA GRANGE
TURLOCK CANAL
DAWSON LAKE
CO.
CO.
STANISLAUS
MERCED
120
49
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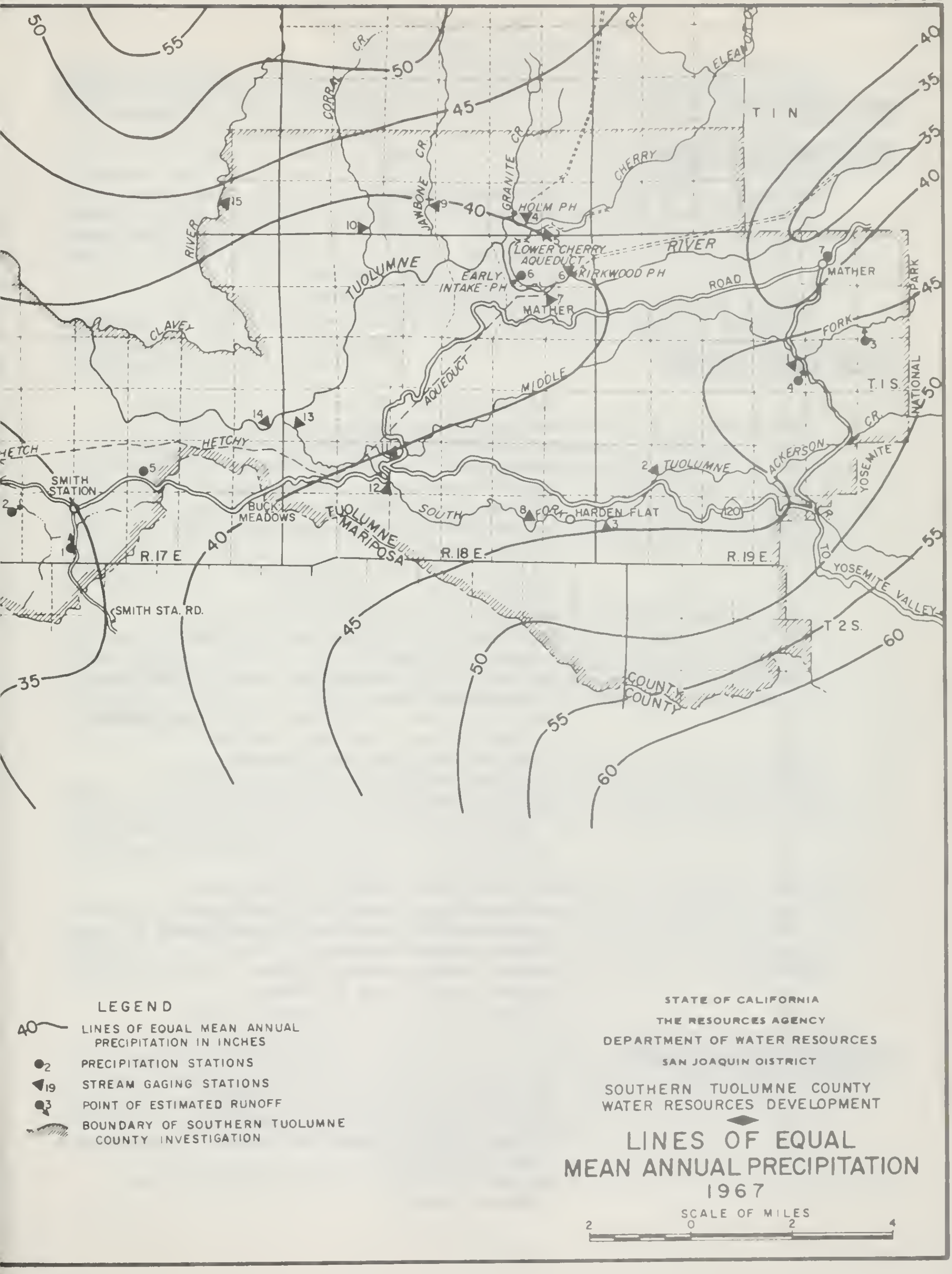


LEGEND
LINES OF EQUAL MEAN ANNUAL PRECIPITATION IN INCHES
PRECIPITATION STATIONS
STREAM GAGING STATIONS
POINT OF ESTIMATED RUNOFF
BOUNDARY OF SOUTHERN TUOLUMNE COUNTY INVESTIGATION
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN DISTRICT
SOUTHERN TUOLUMNE COUNTY
WATER RESOURCES DEVELOPMENT
LINES OF EQUAL
MEAN ANNUAL PRECIPITATION
1967
SCALE OF MILES
2 0 2 4
TUOLUMNE RIVER
CLAVEY
CORRAL CR.
JAWBONE CR.
GRANITE CR.
CHERRY
ELEANOR CR.
HOLM PH
LOWER CHERRY AQUEDUCT
KIRKWOOD PH
EARLY INTAKE PH
MATHER
ROAD
AQUEDUCT
MIDDLE FORK
HETCH HETCHY
SMITH STATION
BUCK MEADOWS
SOUTH FORK
HARDEN FLAT
TUOLUMNE
MARIPOSA
COUNTY
R.17 E.
R.18 E.
R.19 E.
T1N
T1S.
T2S.
ACKERSON CR.
YOSEMITE NATIONAL PARK
TO YOSEMITE VALLEY
SMITH STA. RD.

INDEX TO PRECIPITATION STATIONS
AND STREAM GAGING STATIONS
FOR PLATE 2

PLATE 2 REF. NO.	STATION
PRECIPITATION STATIONS	
1	Don Pedro Reservoir
2	Moccasin
3	Priest
4	Groveland
5	Groveland Ranger Station
6	Early Intake Power House
7	Mather
STREAM GAGING STATIONS	
1	Tuolumne River, Middle Fork, near Mather
2	Tuolumne River, South Fork, at Italian Flat
3	Tuolumne River, South Fork, near Sequoia
4	Cherry Creek, near Early Intake
5	Cherry Creek Canal, near Early Intake
6	Tuolumne River above Early Intake
7	San Francisco Tunnel Diversion, near Hetch Hetchy
8	Golden Rock Ditch, near Sequoia
9	Jawbone Creek, near Tuolumne
10	Corral Creek, near Groveland
11	Tuolumne River, Middle Fork at Oakland Recreation Camp
12	Tuolumne River, South Fork, near Oakland Recreation Camp
13	Tuolumne River, South Fork, near Buck Meadows
14	Tuolumne River, near Buck Meadows
15	Clavey River, near Buck Meadows
16	Big Creek near Groveland
17	Moccasin Power Plant Discharge, near Hetch Hetchy
18	Tuolumne River, near Jacksonville
19	Woods Creek, near Jacksonville
20	Tuolumne River above La Grange Dam
21	Tuolumne River, near La Grange
22	Sierra and San Francisco Power Company Canal, near La Grange
23	Turlock Canal, near La Grange
24	Modesto Canal, near La Grange
25	Tuolumne River, at La Grange Bridge
POINTS OF ESTIMATED RUNOFF	
1	Big Creek at Burch Meadows Damsite
2	Big Creek at Shanahan Flat Damsite
3	Tuolumne River, Middle Fork, at Mather Diversion
4	Unnamed Tributary to Middle Fork at Stone Meadow Damsite

Tuolumne County. Present use of this supply within the area, primarily from direct diversion of unregulated streamflow is very minor and is made for irrigation.

Whether the surface runoff is directly from rainfall or snowmelt is largely dependent upon the elevation of the drainage basin. In the Big Creek Basin, with elevations ranging from 2,400 to 3,700 feet, almost all runoff is from rainfall; whereas in the Middle and South Fork Tuolumne River basins, with elevations ranging from 3,000 to 9,000 feet, most of the runoff is from snowmelt.

Because runoff depends on precipitation, it fluctuates widely from year to year, as does precipitation; furthermore there is a wide variation in streamflow throughout any given year because of the variation in precipitation and snowmelt.

Stream Gaging Stations and Records. Records of streamflow for the Tuolumne River are generally sufficient in number, length, and reliability for hydrologic studies. The drainage areas, periods of record, and sources of record for stream gaging stations in the Tuolumne River Basin are presented in Table 3. Locations of the stations are shown on Plate 2. Most of the runoff records for these stations have been published in the United States Geological Survey Water Supply Papers or in Department of Water Resources bulletins.

The runoff of Big Creek and the Middle and South Forks of the Tuolumne River was of particular interest in the investigation because these streams provide the most likely prospects for local development. The Main Stem of the Tuolumne River and the Clavey River are so deeply entrenched that local development of these streams for this area appears very unlikely.

Gaging stations on the South and Middle Forks just upstream from their confluence have been maintained continuously since March 1923 and October 1916, respectively. Intermittent records at points upstream from these stations have been useful in estimating runoff from the upper portions of the watersheds.

In July 1959 a gaging station was installed on Big Creek near the Groveland damsite in the Northeast Quarter of Section 15, Township 1 South, Range 16 East, MDB and M. The records of flow at this gaging station provide a much more reliable basis for estimating streamflow available to possible projects on Big Creek than was available in prior investigations.

Runoff Estimates. Estimates of natural runoff were made to assist in evaluating potential water conservation projects. The Middle and South Forks of the Tuolumne River and Big Creek offer the most likely possibilities for local water projects. At the present time, man-made impairments to the flow of these streams can be considered as negligible and natural flow is essentially the same as recorded flow.

Records of runoff of the Middle Fork at Oakland Recreation Camp are available for the 50-year period 1916-17 through 1965-66. Records of runoff for the South Fork near Oakland Recreation Camp are available for the period from March 1923 through the water year 1965-66. Estimates of runoff at this station from October 1916 through February 1923 were made by correlation with runoff at the Middle Fork station.

Records of runoff of Big Creek near Groveland are available for the period July 1959 through the water year 1965-66. Estimates of the runoff at this station from October 1916 through June 1959 were made by correlation with Chowchilla River at Buchanan Dam site. The gaging station "Woods Creek Near Jacksonville" was not used for correlation because an undetermined portion of the flow of Woods Creek is derived from imports from the Tuolumne Ditch.

The estimated annual runoff at selected locations in the Tuolumne River Basin for the 50-year period 1916-17 through 1965-66 is shown in Table 4.

The estimated runoff at the Big Creek, Middle and South Fork stations as shown in Table 4 was used to estimate runoff at potential conservation sites. Plate 2 indicates the locations for which runoff was estimated in evaluating possible project features. The runoff at these locations is discussed in Chapter III.

Quality of Surface Water. Analyses of surface water samples collected in 1959 and in 1967 from the Tuolumne River Basin showed that the waters were of excellent mineral quality and were suitable for irrigation and other uses. In addition, the Department has collected samples monthly from the Tuolumne River below Don Pedro since April 1951 as a part of the surface water quality monitoring program. Records of this program indicate that waters flowing in the Tuolumne River were consistently of excellent quality. The waters were characterized by a very low content of total dissolved minerals, chloride, and boron, and by a low percent of sodium. Analyses of surface water samples from minor tributary streams indicate that waters from these sources have a higher mineral concentration than waters from the main stem of the Tuolumne River. Surface water samples collected in 1959 and 1967 indicate that the water in these streams meet U. S. Public Health Standards for drinking water.

Surface waters throughout Tuolumne County are capable of supporting and enhancing an abundant fishery and are of desirable quality for maintenance of the wildlife population.

Table 5 shows the amount of mineral constituents and specific conductance of water samples from the Tuolumne River Basin.

Ground Water

Ground water, by definition, refers only to that water which occurs within the zone of saturation in the open spaces that exist in most of the materials comprising the earth's surface. By this definition, ground water is found under the entire extent of the Southern Tuolumne area.

Where the spaces in the rock comprise a relatively high percentage of the total volume and are inter-connected, the rocks are called water-bearing because substantial amounts of water can be removed from them. If the open spaces in the rock constitute little of the total volume or are not inter-connected, the rock will yield little water and is considered to be nonwater-bearing.

All formations identified within the area, except the alluvium, the glacial moraine, the andesitic volcanic rocks, and the auriferous gravels are crystalline and therefore nonwater-bearing. Wells, when properly located, will drain the inter-connected fractures and joints in these nonwater-bearing rocks and yield flows of 5 to 15 gallons per minute. In the fall months of water-deficient years, these wells frequently fail. Such wells provide most of the present domestic water supplies for rural areas of Southern Tuolumne County not served by the Groveland Community Services District.

Alluvium does not exist in sufficient quantities to be considered as an aquifer in the Southern Tuolumne County area. The andesitic volcanic rocks in Sections 9 and 11, Township 1 South, Range 18 East, and the glacial moraine near Mather are not located near potentially developable service areas and therefore were not studied further. Andesitic volcanic rocks are also found near Smith Station, but because they outcrop on ridges and topographic highs and are therefore above the zone of saturation, these rocks are considered unimportant to ground water except as they serve to conduct percolating waters to the auriferous gravels under them. The auriferous gravels near Smith Station and to the northwest are apparently the only water-bearing rocks near a potential service area in the Southern Tuolumne area. Well production in this unit is somewhat variable. Until a detailed ground water inventory of this area is made, it is impossible to determine the volume of ground water storage available or the safe yield of these gravels.

Quality of Ground Water. Samples of ground water were collected from selected springs and wells within Tuolumne County in 1959 for quality analyses. Only a few samples were collected within the Southern Tuolumne County area. On the basis of suitability for domestic uses, water from some wells did not meet prescribed standards for mineral quality set by the U. S. Public Health Service. For example, water obtained from one well in the vicinity of Yosemite Junction was found to contain slightly more than the allowable limit of arsenic (0.05 milligrams per liter). Other wells in the vicinity of Rawhide Flat and Groveland contain water with more than the recommended limits of the combination of iron and manganese (0.3 milligrams per liter).

In 1955 a well was drilled about three-tenths of a mile east of Groveland for a community water supply system. Water from the well had a high iron content, 3.7 milligrams per liter, which is far above the recommended allowable 0.3 milligrams per liter. Users found the iron content a serious problem, especially in laundering clothes. Other wells in the area have produced water with similar high iron content.

A summary showing the arithmetic averages of the mineral constituents of all available ground water samples is presented in Table 6.

Present Water Development

The runoff from the Tuolumne River Basin is regulated by a series of dams and reservoirs to provide water for irrigation and municipal use, to produce hydroelectric power, and to provide flood protection. The development has been almost entirely by the City and County of San Francisco and the Turlock and Modesto Irrigation Districts. This pattern of development is common for Sierra Nevada streams. Irrigation districts on the valley floor began using substantial quantities of water by the late 1800's, and this use has continued to increase. Public utilities, both privately and publicly owned, initiated hydroelectric power development in the early 1900's. In the case of the Tuolumne River, a metropolitan area (City and County of San Francisco) constructed facilities to export water for municipal use. Because of the earlier economic development of the valley floor and metropolitan areas, these areas were in a financial position to develop water resources, whereas most of the mountainous areas were not.

Modesto and Turlock Irrigation Districts

La Grange Dam and diversion facilities were completed in 1894 and Modesto and Turlock Irrigation Districts were diverting water from the Tuolumne River by 1901. The present diversion facilities at La Grange have a combined capacity of about 4,500 cubic feet per second. Recent diversions at La Grange in acre-feet are as follows:

Water Year	Modesto I. D.1/	Turlock I. D.	Total
1960-61	224,800	372,000	596,800
62	364,600	634,300	998,900
63	359,500	574,700	934,200
64	286,500	522,400	808,900
65	405,800	653,000	1,058,800
5-year average	328,000	551,000	879,000

1/ Includes diversion for Waterford Irrigation District

Don Pedro Dam and Reservoir, a cooperative project by Modesto and Turlock Irrigation Districts, was completed in 1923. It is a multiple-purpose project for irrigation, power, and flood control. The capacity of Don Pedro Reservoir is 290,000 acre-feet and the installed capacity of the power plant is 37,500 kilowatts.

City and County of San Francisco

The passage of the Raker Act by Congress in 1913 paved the way for the construction of the famous Hetch Hetchy System, one of the largest projects in the world for municipal water supply. Reservoirs created by the construction of dams at high elevations in the Sierra Nevada regulate water supplies, and about 140 miles of tunnel and pipeline convey this regulated water from Early Intake Forebay to Crystal Springs Reservoir on the San Francisco Peninsula.

Major reservoirs of the City of San Francisco's project include the following:

Name of Reservoir	Name of Stream	Capacity (acre-feet)
Hetch Hetchy	Tuolumne River	360,000
Lake Lloyd	Cherry Creek	268,000
Lake Eleanor	Eleanor Creek	27,800

Power plants include the following:

Name of Powerplant	Installed Capacity (kw)
Moccasin	70,000
Dion R. Holm	135,000
Robert C. Kirkwood	67,500

Transmission lines convey the power for use in the San Joaquin Valley and metropolitan areas adjacent to San Francisco Bay.

Briefly, the system is operated as follows:

Water stored in Hetch Hetchy Reservoir is conveyed through a tunnel, 10 miles long, to penstocks just upstream from Early Intake Forebay. The penstocks lead to the Robert C. Kirkwood Powerhouse, from which the water is discharged into the Early Intake Forebay. The water then flows through 19 miles of tunnel (Hetch Hetchy Tunnel) to Priest Forebay. Penstocks convey water from Priest Forebay to Moccasin Powerhouse which in turn discharges into Moccasin Afterbay. From Moccasin Afterbay water may be released into the Tuolumne River or conveyed to San Francisco. About 40 percent of the water which passed through Moccasin Powerhouse during recent years has entered the Hetch Hetchy Aqueduct and has been conveyed to service areas at and near San Francisco; the remaining 60 percent has returned to the Tuolumne River and has flowed into Don Pedro Reservoir. In the power developments on Cherry Creek, water released from Lake Lloyd flows through a power tunnel and penstocks to the Dion R. Holm Powerhouse near the junction of Cherry and Granite Creeks. Water released from the Holm Powerhouse flows down Cherry Creek and the Tuolumne River to Don Pedro Reservoir.

The City of San Francisco has under construction the New Moccasin Powerhouse which will have an installed capacity of 90,000 kilowatts. The existing powerhouse will remain intact and be used for peaking power.

Recent exports to the Hetch Hetchy service area in acre-feet are tabulated below.

Water Year	Export to San Francisco
1961-62	175,521
-63	133,632
-64	158,588
-65	169,497
-66	183,041
5-year average	164,056

Under provisions of the Raker Act, the City of San Francisco can export a maximum of 450,000 acre-feet annually, however, prior rights of Modesto, Turlock, and Waterford Irrigation Districts must be considered. Storage is required to provide a firm yield of water, because during dry years there is not sufficient runoff to meet the demands of all Tuolumne River water users. Storage in addition to that provided by existing reservoirs will be required to obtain a firm yield of 450,000 acre-feet annually. Plans for additional storage are discussed in Chapter III.

Local Development and Use of Water

The only cooperative development of a domestic water supply in Southern Tuolumne County is the Groveland Community Services District System. The original system was constructed in 1955, and water was pumped from a well. The well subsequently became an unsatisfactory source of supply from the standpoint of both quantity and quality of water. In late 1965, facilities were constructed whereby Hetch Hetchy Aqueduct became the source of supply. The facilities, which cost about $140,000, were financed by a Davis-Grunsky loan administered by the Department of Water Resources. They consist primarily of a submersible pump in the Second Garrotte Shaft, a pipeline leading from the pump to a 500,000-gallon storage tank on a hillside above Groveland, and a pipeline from the tank leading to the distribution system which serves about 70 connections in the community of Groveland. The citizens of Big Oak Flat have petitioned for annexation to the District in order to obtain a reliable water service for their community.

Except for Groveland, domestic water is supplied from wells. Most of these wells are in the upland soils, which can be considered essentially as nonwater bearing. The yields from these wells are low and in many instances the quality is poor because of high iron concentrations.

Bulletin No. 96 reported that use of water in year 1960 in Southern Tuolumne County was estimated to be 250 acre-feet annually for irrigated agriculture and 160 acre-feet annually for domestic use. It was beyond the scope of this investigation to re-evaluate the land and water use projections for all of Southern Tuolumne County.

TABLE 1

MEAN, MAXIMUM, AND MINIMUM ANNUAL[1/] PRECIPITATION
AT SELECTED STATIONS IN OR NEAR SOUTHERN TUOLUMNE COUNTY

Station	County	Elevation in Feet	Period of Record	Source of Record[2/]	Mean Annual Precipitation, in Inches	Maximum and Minimum Annual Precipitation: Year	Inches
Coulterville	Mariposa	1,870	1959-present	CDF	26.51	1964-65 1960-61	36.57 17.01
Don Pedro Reservoir	Tuolumne	700	1940-present	SFPUC	18.51	1957-58 1958-59	29.10 11.58
Dudleys	Mariposa	3,000	1909-present	USWB	37.27	1910-11 1923-24	57.18 18.41
Early Intake Powerhouse	Tuolumne	2,356	1925-present	SFPUC	31.82	1937-38 1958-59	52.29 19.97
Groveland[3/]	Tuolumne	2,825	1930-present	USWB	33.92	1937-38 1960-61	57.64 20.59
Groveland Ranger Sta.	Tuolumne	3,135	1940-present	USWB	35.82	1955-56 1960-61	52.94 22.56
Hetch Hetchy	Tuolumne	3,670	1910-present	USWB	33.73	1937-38 1923-24	55.62 17.03
Lake Eleanor	Tuolumne	4,662	1911-present	USWB	40.63	1937-38 1958-59	64.61 21.00
Mather	Tuolumne	4,518	1931-33 1955-present	USWB	31.93	1955-56 1958-59	45.90 23.57
Moccasin	Tuolumne	950	1936-present	SFPUC	27.24	1937-38 1960-61	41.20 17.01
Priest	Tuolumne	2,245	1930-present	SFPUC	26.75	1957-58 1930-31	42.47 16.57
Sonora	Tuolumne	1,830	1888-present	USWB	30.61	1889-90 1923-24	67.39 13.67
Yosemite National Park	Mariposa	3,965	1907-present	USWB	34.34	1937-38 1923-24	58.64 14.77

1/ July 1 through June 30
2/ USWB = United States Weather Bureau
SFPUC = San Francisco Public Utility Commission
CDF = California Division of Forestry
3/ Groveland #1 1930-1941 (standard rain gage)
Groveland #2 1941-present (recording rain gage)

TABLE 2

RECORDED ANNUAL1/ PRECIPITATION AT SELECTED STATIONS IN SOUTHERN TUOLUMNE COUNTY
(In Inches)

Precipitation Year	Don Pedro Reservoir	Groveland	Lake Eleanor
1910-11	-	-	59.35
-12	-	-	25.43
-13	-	-	27.27
-14	-	-	55.16
-15	-	-	43.92
1915-16	-	-	41.40
-17	-	-	44.63
-18	-	-	31.68
-19	-	-	35.46
-20	-	-	30.21
1920-21	-	-	40.81
-22	-	-	36.72
-23	-	-	40.08
-24	-	-	20.83
-25	-	-	48.15
1925-26	-	-	31.60
-27	-	-	46.35
-28	-	-	44.01
-29	-	-	29.45
-30	-	25.83	30.49
1930-31	-	20.76	29.99
-32	-	40.75	54.14
-33	-	21.58	32.34
-34	-	24.98	28.70
-35	-	43.36	54.99
1935-36	-	43.06	48.06
-37	-	41.46	45.98
-38	-	57.64	64.61
-39	-	25.73	30.79
-40	-	44.50	54.08

Precipitation Year	Don Pedro Reservoir	Groveland	Lake Eleanor
1940-41	24.74	46.04	55.16
-42	22.74	42.40	52.16
-43	20.12	42.71	53.85
-44	16.92	32.68	36.74
-45	22.97	40.54	48.82
1945-46	19.01	36.32	46.63
-47	13.67	24.51	35.43
-48	18.59	30.07	37.50
-49	15.45	30.48	32.67
-50	16.80	30.51	35.59
1950-51	23.35	39.03	58.37
-52	27.20	48.82	59.67
-53	17.15	27.33	36.32
-54	16.37	30.59	42.29
-55	15.28	25.52	30.48
1955-56	27.61	48.84	60.90
-57	15.22	28.05	36.03
-58	29.10	48.14	48.49
-59	11.58	22.02	21.00
-60	16.52	30.01	30.32
1960-61	M2/	20.59	21.04
-62	20.15	35.77	41.59
-63	21.52	M	41.48
-64	16.73	23.67	26.40
-65	22.49	45.07	44.10
-66	16.46	29.25	30.18

1/ July 1 through June 30
2/ M - Missing record

TABLE 3

STREAM GAGING STATIONS IN OR NEAR SOUTHERN TUOLUMNE COUNTY

Stream	Station	Drainage: Area, in: Sq. Mi.	Periods of Record	Source of Records[1/]
Big Creek	near Groveland	25	1931-33 1959-present	USGS
Cherry Creek Canal	near Early Intake	---	1956-present	USGS
Cherry Creek	near Early Intake	226	1956-present	USGS
Cherry Creek	below Cherry Valley Dam	118	1956-present	USGS
Cherry Creek	near Hetch Hetchy	111	1910-1955	USGS
Clavey River	near Buck Meadows	140	1959-present	USGS
Corral Creek	near Groveland	---	1910-1913	USGS
Eleanor Creek	near Hetch Hetchy	80	1909-present	USGS
Golden Rock Ditch	near Sequoia	---	1914-1915	USGS
Jawbone Creek	near Tuolumne	20	1910-1914	USGS
Moccasin Power-plant Discharge	near Hetch Hetchy	---	1936-present	SFPUC
Modesto Canal	near La Grange	---	1903-present	USGS
San Francisco Tunnel Diversion	near Hetch Hetchy	---	1932	SFPUC
Sierra and San Francisco Power Company Canal	near La Grange	---	1908-1926	USGS
Tuolumne River	at La Grange Bridge	---	1937-present	DWR & TID
Tuolumne River	near La Grange	1,540	1895-1915	USGS
Tuolumne River	above La Grange Dam	1,534	1915-present	USGS
Tuolumne River	near Jacksonville	1,352	1923-34	USGS
Tuolumne River	near Buck Meadows	934	1907-1909 1911-1936	USGS
Tuolumne River	above Early Intake	---	1939-present	USGS
Tuolumne River	near Hetch Hetchy	462	1914-present	USGS
Tuolumne River, South Fork	near Buck Meadows	163	1910-1922	USGS
Tuolumne River, South Fork	near Oakland Recreation Camp	88	1923-present	USGS
Tuolumne River, South Fork	near Sequoia	70	1914-1918	USGS
Tuolumne River, South Fork	at Italian Flat	67	1924-1930 1931-1933	USGS
Tuolumne River, Middle Fork	at Oakland Recreation Camp	71	1910-present	USGS
Tuolumne River, Middle Fork	near Mather	52	1924-present 1931-1933	USGS
Turlock Canal	near La Grange	---	1899-present	USGS
Woods Creek	near Jacksonville	98	1924-present	USGS

1/ USGS - United States Geological Survey
SFPUC - San Francisco Public Utility Commission
TID - Turlock Irrigation District
DWR - California Department of Water Resources

TABLE 4

ESTIMATED ANNUAL[1] NATURAL RUNOFF AT SELECTED LOCATIONS
IN THE TUOLUMNE RIVER BASIN
(In Thousands of Acre-feet)

Water Year	Big Creek near Groveland	Tuolumne River near Hetch Hetchy	Middle Fork Tuolumne River at Oakland Recreation Camp	South Fork Tuolumne River near Oakland Recreation Camp	Tuolumne River above La Grange: Annual[2] Runoff	Tuolumne River above La Grange: Percent of 50-Year Average
1916-17	15.8	876	75	94	2,220	129
18	8.0	572	44	55	1,460	85
19	5.7	641	38	48	1,340	78
20	5.8	553	37	46	1,340	78
1920-21	8.8	782	59	74	2,018	118
22	18.1	936	82	103	2,471	144
23	14.0	683	58	72	1,786	104
24	0.8	263	14	20	537	31
25	5.2	857	61	62	1,932	113
1925-26	3.4	518	34	39	1,110	65
27	11.5	885	61	76	2,051	120
28	6.5	617	44	50	1,525	89
29	1.3	467	27	32	969	57
30	1.8	536	28	30	1,146	67
1930-31	0.2	297	12	16	602	35
32	15.8	860	61	71	2,114	123
33	2.3	537	29	35	1,104	64
34	1.4	358	16	22	807	47
35	14.2	869	70	85	2,103	123
1935-36	17.0	878	67	76	2,160	126
37	19.5	797	66	88	1,997	116
38	37.4	1,275	133	185	3,424	198
39	3.2	436	26	38	981	57
40	14.5	846	61	84	2,207	129
1940-41	22.8	1,004	82	114	2,489	145
42	12.9	1,020	86	113	2,356	137
43	14.6	937	78	107	2,370	138
44	4.5	584	40	54	1,295	76
45	12.2	882	66	92	2,085	122
1945-46	5.5	811	68	80	1,874	109
47	2.7	538	31	41	1,094	64
48	3.3	670	40	45	1,406	82
49	3.0	565	34	42	1,246	73
50	3.7	708	42	47	1,545	90

TABLE 4 (Continued)

ESTIMATED ANNUAL[1] NATURAL RUNOFF AT SELECTED LOCATIONS
IN THE TUOLUMNE RIVER BASIN
(In Thousands of Acre-feet)

Water Year	Big Creek near Groveland	Tuolumne River near Hetch Hetchy	Middle Fork Tuolumne River at Oakland Recreation Camp	South Fork Tuolumne River near Oakland Recreation Camp	Tuolumne River above La Grange: Annual[2] Runoff	Tuolumne River above La Grange: Percent of 50-Year Average
1950-51	14.3	993	77	93	2,532	147
52	21.1	1,129	105	130	2,982	174
53	4.0	676	41	50	1,525	89
54	3.5	589	44	54	1,429	83
55	2.2	514	28	35	1,124	66
1955-56	22.8	1,258	115	126	3,152	184
57	2.5	646	42	50	1,416	83
58	19.8	990	88	111	2,638	154
59	2.0	434	25	32	990	58
60	3.1	469	25	34	1,052	61
1960-61	0.5	376	15	17	732	43
62	9.6	783	48	59	1,765	103
63	10.6	838	58	77	2,041	119
64	1.4	485	27	32	1,130	66
65	14.1	1,058	78	91	2,738	160
66	4.6	624	39	50	1,306	76
Average[3]	9.0	718	52	66	1,714	100

1/ October 1 through September 30.
2/ Summarized from estimates made by the City of San Francisco on a daily basis.
3/ Average for 50-year period 1916-17 through 1965-66.

TABLE 5

MINERAL ANALYSES OF REPRESENTATIVE SURFACE WATERS OF THE TUOLUMNE RIVER BASIN

Location	Date of Sample	Conductance at 25°C (EC x 10^6)	Mineral Constituents, in Milligrams per Liter								
			Boron	Calcium	Magnesium	Sodium	Bicarbonate plus Carbonate	Chloride	Sulfate	Nitrate	Percent Sodium
Hunter Creek near Tuolumne	6-16-59	108	0.07	14	1.4	4.2	56	2.5	1.0	0.6	17
North Fork Tuolumne River near Tuolumne	6-16-59	78	0.07	8.2	1.3	4.6	42	1.0	0.6	0.8	27
North Fork Tuolumne River near Long Barn	6-15-59	69	0.10	7.2	1.2	4.0	38	1.5	0.0	0.9	25
Clavey River near Tuolumne	6-16-59	36	0.10	3.3	0.7	2.1	16	1.0	0.8	0.7	27
Tuolumne River at Lumsden Bridge	6-16-59	17	0.10	1.9	0.4	1.2	8	1.0	0.6	0.6	28
Big Creek near Groveland Gaging Station	1-10-67	121	0.0	11.0	2.1	7.8	39	5.7	12.0	1.2	31
Arithmetic Average of All Samples		71	0.07	7.6	1.2	4.0	33	2.1	2.5	0.8	26

TABLE 6

MINERAL ANALYSES OF GROUND WATER FROM REPRESENTATIVE WELLS WITHIN TUOLUMNE COUNTY[1/]

Item	Conductance, at 25°C ($EC \times 10^6$)	Mineral Constituents in Milligrams per Liter								Percent Sodium
		Boron	Calcium	Magnesium	Sodium	Bicarbonate + Carbonate	Chloride	Sulfate	Nitrate	
Arithmetic average of 10 samples	501	0.11	45	28	18	259	12	30	9.0	14

1/ From samples taken in 1959

CHAPTER III. FUTURE WATER DEVELOPMENT

Future water developments in Southern Tuolumne County will probably play an important part in the overall development of the area. Construction of the New Don Pedro Project by the Turlock and Modesto Irrigation Districts and the City and County of San Francisco will create new recreation resources in the Southern Tuolumne County foothills. The operation and maintenance of the Hetch Hetchy Project by the City and County of San Francisco, including probable future expansions, will contribute in the future to the local area. The most significant future benefits to the local area, however, would result from local water projects as proposed in this report.

Future Development by Turlock and Modesto Irrigation Districts and the City and County of San Francisco

New Don Pedro Dam and Reservoir, a joint enterprise of Turlock and Modesto Irrigation Districts and the City and County of San Francisco, is scheduled for construction in the near future. The new dam is to be located about one mile downstream from the existing dam and will create a reservoir with a capacity of 2,030,000 acre-feet.

New Don Pedro is a multiple-purpose project for irrigation, municipal water supply, power, flood control, recreation and fish enhancement. The enlarged reservoir will regulate Tuolumne River flows to a far greater extent than the existing 290,000 acre-foot reservoir and will provide a greater firm yield of water for both the Irrigation Districts and the City and County of San Francisco. The New Don Pedro Powerhouse will have an installed capacity of 150,000 kilowatts, an increase of 112,500 kilowatts over that of the existing powerhouse.

Although the City of San Francisco will not physically obtain its water from New Don Pedro Reservoir, releases of the City's water from New Don Pedro Reservoir for use downstream will be in exchange for water to be exported by the Hetch Hetchy System.

Turlock and Modesto Irrigation Districts have filed an application for a Davis-Grunsky grant for the portion of the costs of New Don Pedro Dam and Reservoir to be allocated to recreation and fish and wildlife enhancement. The District's proposed plans for recreation development call for major recreation facilities in the vicinity of the new dam and other facilities at Moccasin Point.

In addition to its participation in the construction of New Don Pedro Dam and Reservoir, the City has plans for enlarging Lake Eleanor. Although Lake Eleanor lies just outside Southern Tuolumne County, access to Lake Eleanor is through Southern Tuolumne County and the water from Lake Eleanor is used for power generation at the Dion R. Holm Powerhouse. Water from Lake Eleanor must flow through a tunnel into Lake Lloyd thence into the Holm Powerhouse. At the present time the maximum water level in Lake Eleanor is about 40 feet lower in elevation than the maximum water level in Lake Lloyd. The proposed enlargement of Lake Eleanor will increase the firm yield and thereby enhance the operation of the two reservoirs.

Another potential hydroelectric power project in Southern Tuolumne County is a project to use the regulated flow from the Holm Powerhouse. About 1,400 feet of head is available between the Holm Powerhouse and New Don Pedro Reservoir.

Previous Proposals for Local Development

The Department of Water Resources is the only agency that has conducted a comprehensive water resources investigation of Southern Tuolumne County, and the results were published in a preliminary edition of Bulletin No. 96, entitled "Southern Tuolumne County Investigation". Reservoirs studied during that investigation included the proposed Harden Flat, Burch Meadows and Groveland Reservoirs. These three reservoirs, as presented in Bulletin No. 96, are discussed below.

Harden Flat Dam and Reservoir

The Harden Project (a multiple-purpose project including power, recreation, fish enhancement, and domestic water supply) included an earthfill dam on the South Fork of the Tuolumne River at Harden Flat. The dam would create a reservoir having a capacity of 42,000 acre-feet and a surface area of 430 acres. The primary purpose of this feature of the project was power with recreation of secondary importance.

Burch Meadow Dam and Reservoir

The Harden Project included a Burch Meadow Dam and Reservoir to be formed by construction of a modified homogeneous earthfill dam on Big Creek near Smith Station. The dam would create a reservoir having a capacity of 3,550 acre-feet and a surface area of 188 acres. Because of the small watershed area tributary to the damsite (2.4 square miles), an import of water from Harden Flat was proposed for initial filling and to maintain a full reservoir. The purposes of Burch Meadow Reservoir were recreation and domestic water supply.

Groveland Dam and Reservoir

The proposed "Groveland Project" included an earthfill dam on Big Creek approximately 2 miles northeast of the community of Groveland. The dam would create a reservoir having a capacity of 40,000 acre-feet and a surface area of 570 acres. The purposes of the reservoir were power, domestic water supply and recreation. Most of the inflow to the reservoir would be supplied by diversion of the South Fork

Tuolumne River at Harden Flat into the headwaters of Big Creek near Groveland Ranger Station. A minor portion of the inflow would be from the natural runoff of Big Creek.

Recreation Potential of Southern Tuolumne County

The scarcity of public water-associated recreation has hampered the economic development of Southern Tuolumne County. Water-associated recreation in the national park portion of the area is confined to a few accessible stream sites. The U. S. Forest Service lists 48 camp units within 5 miles of Highway 120 between Groveland and the Yosemite National Park Boundary. Although the variety of recreation opportunity at these camp sites is limited, the camp sites are used to capacity. Furthermore, many campers are using undesignated camping areas which have no facilities available. Recreation reservoirs as proposed herein for the central and eastern portion of Southern Tuolumne County would provide additional facilities with greater variety of recreation opportunities and would enhance the natural beauty of the area.

New Don Pedro Reservoir will create new recreation resources and will provide additional recreation facilities in the foothill region. The reservoir, which will be located in the foothill area at an elevation of about 800 feet, will satisfy a demand for water-associated recreation activities such as warm water fishing, boating, and water skiing. It will not satisfy a demand for camping, picnicking, hiking, and sight-seeing in the mountainous and forested areas to the east which have the advantages of a cooler climate, seclusion and natural beauty.

There are many reasons why Southern Tuolumne County can be considered as having an excellent potential for the development of water-associated recreation facilities. Among these are:

1. Access to proposed water-associated recreation developments is excellent. This type of development would be within 3 miles of Highway 120, the northern entrance to Yosemite National Park, which traverses the area. Highway 120 is the shortest route to Yosemite National Park from the San Francisco Bay, Sacramento, and Stockton metropolitan areas. In addition, many out-of-state visitors from the Pacific Northwest and from the East via Highway 80 will use this route to Yosemite.

   The use of Highway 120 as a route to Yosemite is expected to increase greatly as a result of planned improvements. In November 1966, the National Park Service designated it an all-year highway. The recently completed reach from Buck Meadows to Crane Flat is a high speed, two-lane highway. There remains a 25-mile reach from Chinese Camp to Buck Meadows which is steep, winding and narrow in many places. The portion of this reach from Chinese Camp to Priest will be relocated and improved when the New Don Pedro Project is built.

2. There is a scarcity of recreation reservoirs in this portion of the Sierra Nevada. The closest recreation reservoir south of the Tuolumne River is Bass Lake, in Madera County, a straightline distance of 38 miles to the south. The actual distance by highway through Yosemite Valley is much greater.

3. The area has scenic beauty and climate suitable for recreation developments. The Tuolumne River Gorge drops from 1,000 to 2,000 feet from the adjacent lands in the central portion of the area and forms an interesting escarpment along the northern boundary. Attractive meadow lands as well as moderately to heavily forested lands are available as recreation sites. Nighttime temperatures are much more pleasant than in the foothills and valley.

4. Additional camping facilities in Southern Tuolumne County would help alleviate the over-use of facilities and congestion in Yosemite National Park. The Park Service plans to eliminate the uncontrolled and haphazard camping of the past. Camp areas will be divided into camp sites, and tents will be spaced farther apart. Because of these changes in National Park policies concerning camping in Yosemite Valley, many future visitors to Yosemite will have to camp outside the Park. Camping facilities proposed in Southern Tuolumne County would offer the camper a pleasant side trip into the Park.

The above specific reasons combined with the general reasons of (1) population increase, (2) more leisure time, and (3) improved means of transportation will result in a great increase in demand for recreation facilities in Southern Tuolumne County.

Domestic Water Demands

Domestic water demands for Southern Tuolumne County were estimated by using projections of population and unit delivery requirements. The projections of population and the unit delivery requirements were based on a reappraisal of studies conducted for the Southern Tuolumne Investigation.

Population Projections

A review of population projections for Southern Tuolumne County presented in Bulletin No. 96 indicated that the projections were reasonable. Classification of population types in Bulletin No. 96 included urban, suburban, rural, and recreation. Urban, suburban, and rural residents were considered to be year-round residents; recreation residents included those residing in summer homes, motels, hotels, and trailer parks. In this investigation, suburban and rural residents were combined under the classification of rural. The following is a tabulation of year 1960 and predicted year 2020 populations in Southern Tuolumne County.

Population Type	Population Year 1960	Year 2020
Urban	350	2,300
Rural	710	5,700
Recreation	180	1,600

Unit Delivery Requirements

Information on water use obtained since the Southern Tuolumne Investigation was completed indicates that a lower value for unit delivery requirement should be used. Unit delivery requirements are the measure of domestic use and are expressed in gallons per capita per day. The following tabulation of projected unit delivery requirements were used for determining water requirements in the Southern Tuolumne County study area.

Population Type	Projected Unit Delivery Requirement in Gallons per Capita per Day Year 1975	Year 2025
Urban	130	230
Rural	110	185
Recreation	90	140

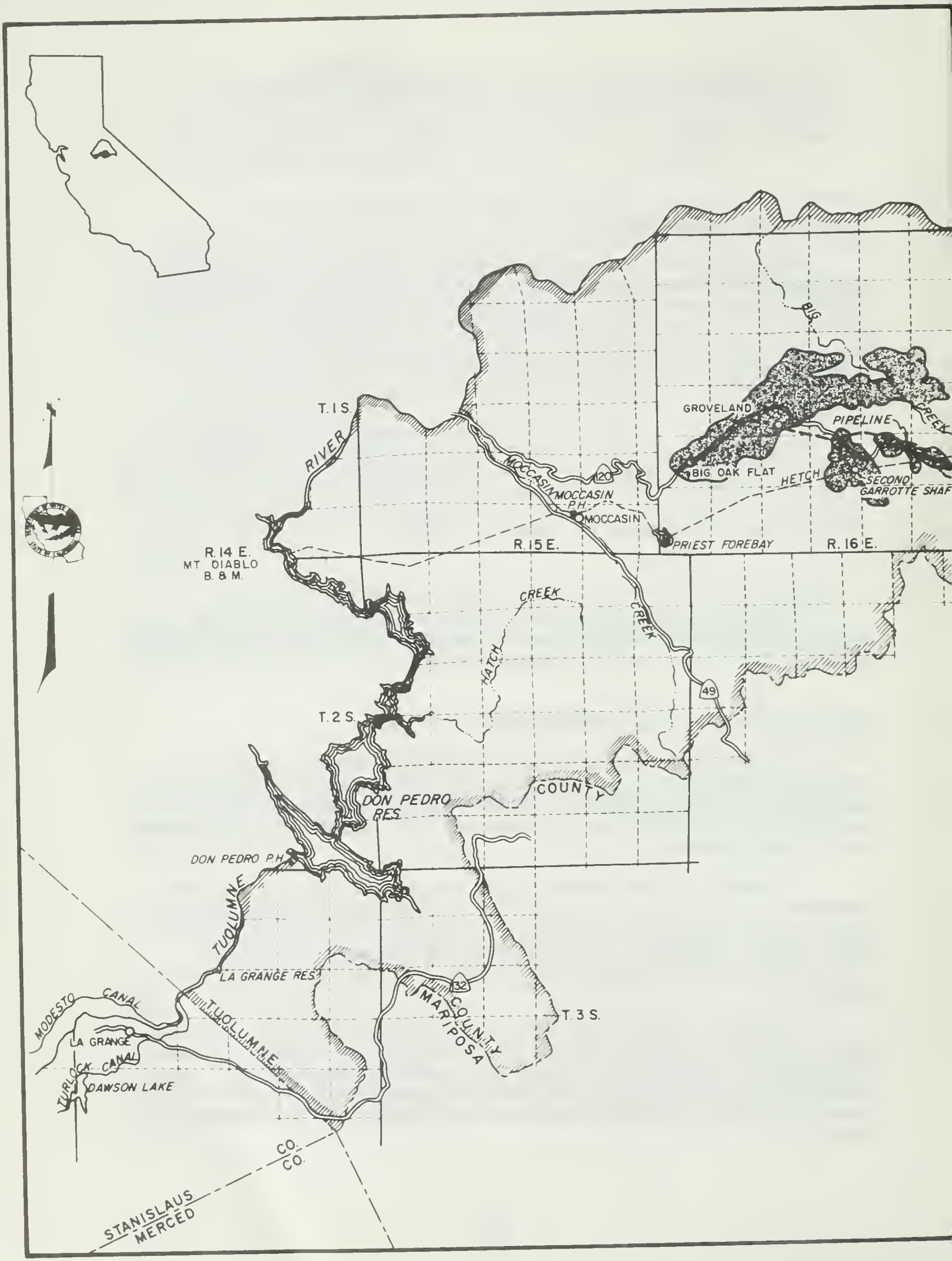
It is estimated that approximately 50 percent of the unit delivery requirements tabulated above would be consumptively used and the remainder would return to the Tuolumne River.

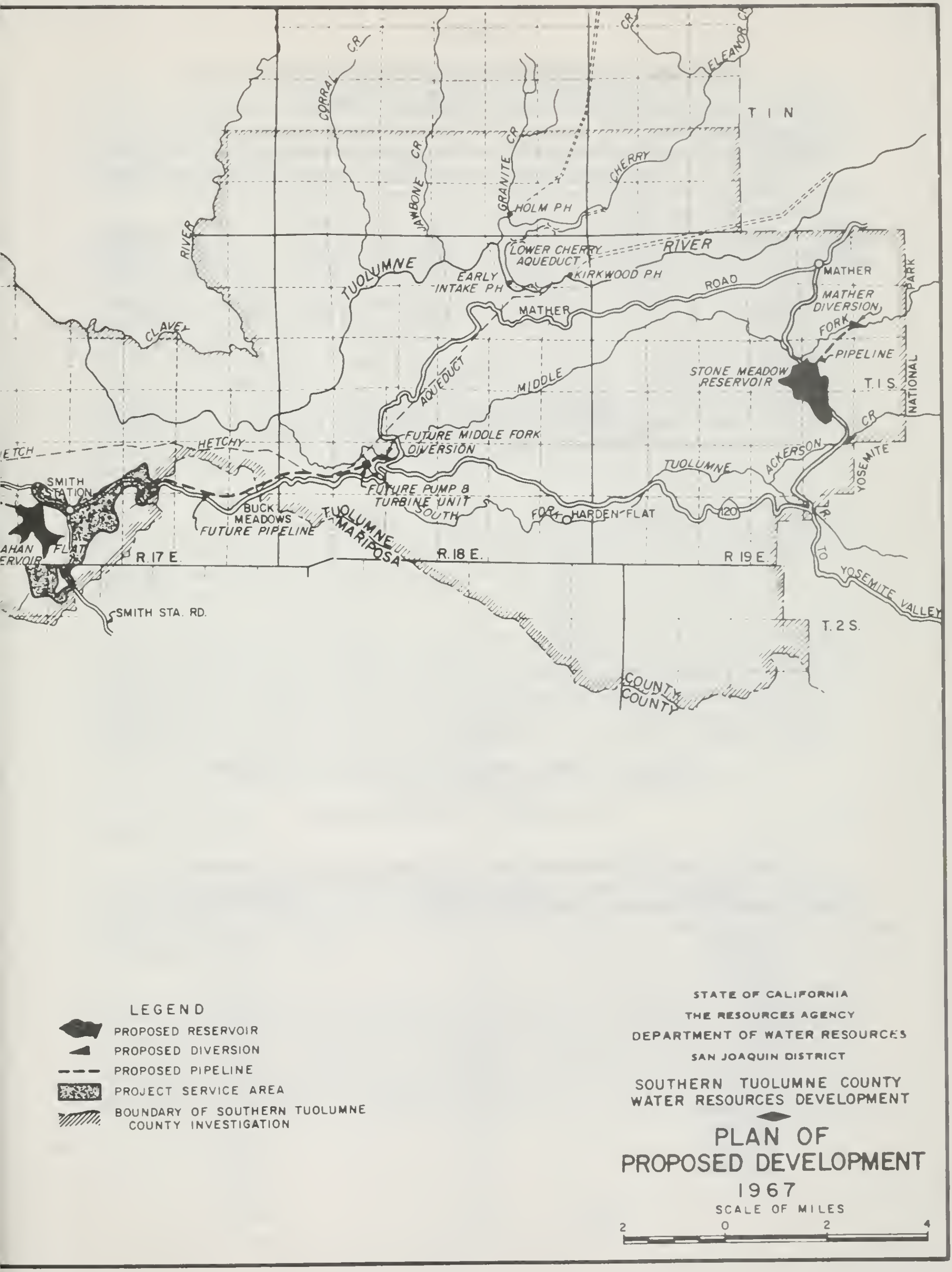
Project Service Area and Water Demands

The project service area is delineated on Plate 3, "Plan of Proposed Development". The boundaries of this area were determined by land classification, estimated location of future residential growth, status of land ownership and the feasibility of supplying domestic water from a single source.

Domestic water demands within the project service area were estimated on the basis of the projected population within the service area and the unit delivery requirements tabulated in the previous section. Table 7 presents the projected population within the project service area, and Table 8 presents the estimated annual domestic water demand.

Domestic demands for water vary throughout the year and are greater during the summer because of the watering of lawns and gardens. The sizing of conveyance facilities and terminal storage depends upon variations in quantities of use. Table 9 presents the estimated monthly domestic water demand expressed as a percent of the annual demand.


T. 1 S.
RIVER
R. 14 E.
MT DIABLO
B. & M.
T. 2 S.
DON PEDRO RES.
DON PEDRO P.H.
TUOLUMNE
LA GRANGE RES.
MODESTO CANAL
LA GRANGE
TURLOCK CANAL
DAWSON LAKE
TUOLUMNE
MARIPOSA
COUNTY
T. 3 S.
STANISLAUS CO.
MERCED CO.
MOCCASIN
MOCCASIN P.H.
MOCCASIN
120
R. 15 E.
CREEK
HATCH
CREEK
49
COUNTY
GROVELAND
BIG OAK FLAT
PRIEST FOREBAY
HETCH
PIPELINE
SECOND GARROTTE SHAF
R. 16 E.
BIG
CREEK



STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
SAN JOAQUIN DISTRICT

SOUTHERN TUOLUMNE COUNTY WATER RESOURCES DEVELOPMENT

PLAN OF PROPOSED DEVELOPMENT

1967

TABLE 7

PROJECTED POPULATION WITHIN THE PROJECT SERVICE AREA
(In Number of Permanent Residents)

Type of Use	Year 1975	1985	1995	2005	2015	2025
Urban	340	420	570	840	1,290	2,000
Rural	610	930	1,410	2,230	3,700	6,030
Recreation	120	160	220	290	390	540
Totals	1,070	1,510	2,200	3,360	5,380	8,570

TABLE 8

ESTIMATED ANNUAL DOMESTIC WATER
DEMAND WITHIN THE PROJECT SERVICE AREA
(In Acre-feet)

Year	Demand
1975	150
1985	240
1995	390
2005	650
2015	1,110
2025	1,890

TABLE 9

ESTIMATED MONTHLY DEMANDS FOR WATER IN SOUTHERN
TUOLUMNE COUNTY
(In Percent of Annual Demands)

Month	Type of Domestic Use: Urban & Rural	Recreation
January	5.4	1.4
February	5.3	1.6
March	5.4	1.8
April	6.0	2.3
May	7.2	12.1
June	10.2	20.3
July	13.8	23.7
August	13.8	23.7
September	12.5	7.2
October	8.7	3.2
November	6.2	1.3
December	5.5	1.4
Totals	100.0	100.0

Planning Considerations

The first step in planning a local water project for Southern Tuolumne County was to identify possible project purposes. Information from prior investigations indicated that irrigation, power, and flood control would probably not prove to be justifiable.

Land classification surveys made for Bulletin No. 96 showed 8,430 acres of potentially irrigable agricultural lands in Southern Tuolumne County. It was found, however, that no project could be formulated which would supply water for commercial agriculture at a cost within the ability of the users to pay. Cursory estimates made during this investigation have supported that conclusion.

The Harden Project presented in Bulletin No. 96 was found to have the greatest potential of several alternatives to develop the water resources of Southern Tuolumne County, based on the inclusion of power as a project purpose. As previously mentioned, the power function of the project has become economically unjustified because of increased construction costs and decreased values for hydroelectric energy.

The New Don Pedro Project will provide flood control storage space in such an amount that potential flood control benefits for other projects on the Tuolumne River would be small. Since no significant flood problems were found in the area, flood control was not included as a possible project purpose.

Thus the primary consideration in formulating projects during this investigation was for the purposes of recreation, fish and wildlife enhancement, and domestic water supply. With recreation as a primary project purpose, the important factors in the selection and sizing of reservoirs included natural beauty, accessibility, and the location and availability of land suitable for recreation. For these reasons additional reservoir sites were considered.

Geologic Studies

Geologic studies conducted for this investigation consisted of surficial geologic reconnaissance studies of possible storage dam and reservoir sites, diversion damsites, and conduit routes. A brief evaluation was made of the type and location of materials suitable for construction of embankment-type dams.

Studies of storage dams included identification of channel and abutment foundation rock formations, estimates of stripping and grouting, and recommendations of types and locations for the embankment, spillway, and outlet works. Estimates of the source, available quantity, and suitability of embankment construction materials were included. The possibility of reservoir leakage was noted.

Geologic studies of potential diversion damsites consisted of surficial investigations, including identifications of channel and abutment rock formations and estimates of stripping and trimming. No construction problems were anticipated.

From the geologic standpoint, all possible features investigated were found to be engineeringly feasible.

Designs and Cost Estimates

Designs and cost estimates with one exception were made for possible project features to the degree of detail used by the Department in reconnaissance level studies. Possible project features included storage dams and reservoirs, recreation facilities, diversion dams, pipelines, pumping plants, a pump-turbine plant, and water treatment facilities. The one exception was that recreation facilities costs were based on a unit cost per capacity basis. The unit cost was determined for a similar type recreation reservoir located in the Sierra Nevada.

Project features were designed in accordance with standard engineering practices. Alternative designs were evaluated to assure that the most economical design would be considered for a given size or capacity of a project feature.

Estimates of capital costs of all project features, present and future, were based on prices prevailing in 1967 and incuded costs of construction, land acquisition, and road relocation. The cost of acquisition of private lands and improvements for reservoirs and recreation purposes was based upon market data obtained from recent sales in the area. Ownerships of lands and improvements were determined from the Tuolumne County assessor's office, and the boundaries of acquisition are based thereon.

Estimates of capital costs include allowances for engineering, administration, construction contingencies, and interest during construction.

Estimates of annual costs include replacement, operation, maintenance, and amortization of the capital investment during a 50-year repayment period at an interest rate of four percent. No allowance was made for escalation of future capital or annual costs.

Estimates of Benefits

Project purposes include recreation, fish enhancement, and domestic water supply. A review of project proposals by the California Department of Fish and Game indicated that project proposals would have no wildlife enhancement benefits; but rather a slight detriment would be caused by the inundation of wildlife habitat.

Recreation Benefits. Estimates of anticipated recreation benefits were made to evaluate this function of the proposed projects. Recreation benefits are estimated by multiplying a monetary value assigned for a visitor-day[1/] of use by the number of anticipated visitor-days attributable to the project.

The unit value for a visitor-day and the number of anticipated visitor-days have been estimated in a general manner for this study. These estimates should be refined by more detailed recreation use studies before any project described herein is proposed for construction.

The Departments of Water Resources and Parks and Recreation have adopted a "Statement of Guidelines" for evaluating recreation activity and resources in connection with water resources development. This statement of guidelines provides for general recreation benefits in terms of two factors: (1) variety and quality of recreation, and (2) esthetic qualities of the site. The statement specifies that these factors are to be given equal weight and that the sum of the factor ratings will be used in establishing the unit value per visitor-day of use within a $0.50 to $2.50 range. A detailed description of this method of estimating unit values of general recreation use is presented in Appendix A.

Projections of the amount of recreation use were made from extensions of State and Stanislaus National Forest trends, which were assumed to continue. These projections indicate that in 1970, 2.76 percent of all camping in California will occur in the Stanislaus National Forest and that 25 percent of the Stanislaus National Forest use will occur in Southern Tuolumne County. Based on these projections, camping in Southern Tuolumne County was estimated to be 250,000 visitor-days annually in 1975, increasing to 665,000 visitor-days annually in 2005. Day use projections were derived in the same manner. Day use projections indicate 100,000 visitor-days annually by the year 1975, increasing to 265,000 visitor-days annually by the year 2005.

Estimates of visitor-day use at proposed recreation reservoirs are presented in Chapter V.

Fish Enhancement Benefits. The State Department of Fish and Game has evaluated the fishery potentials of the possible reservoir sites. These studies provided the basis for estimates of angler-day[2/] use at the proposed reservoirs. Anticipated fish enhancement benefits were based on the proportionate number of visitor-days which would result from the reservoir fishery. The same unit value was used for fish enhancement as for other types of recreation.

1/ One visitor-day represents use by one visitor for any portion of a day regardless of the number of activities in which he participates.

2/ Angler-day is similar to visitor-day of recreation use with angling as a primary activity.

Domestic Water Supply Benefits. The "Alternative Cost Method" was used to estimate benefits that would accrue from domestic use of water from a proposed project. In this method, alternative projects to supply water of equivalent quality to the same point of use as the proposed project are evaluated. The least costly alternative limits the measure of benefits to be derived from the proposed project. Alternative sources considered were ground water, direct diversion of streamflow, the Hetch Hetchy Aqueduct, and possible storage projects.

Operation Studies

Reservoir operation studies were made to determine the availability of water during critically dry periods to supply domestic water demands and provide for evaporation losses. The operation studies also provided pertinent information on reservoir drawdown assuming a repetition of runoff that occurred during the 40-year period 1926-27 through 1965-66. The amount and timing of drawdown has an important bearing on recreation and fish enhancement benefits.

Proposed operations are shown in Tables 28 through 33 of Appendix B.

Water Rights. Water rights were considered in planning the proposed dams and reservoirs. Proposed reservoirs would alter the amount and pattern of runoff from streams and thereby affect the water available to downstream users.

This report does not purport to interpret or adjudge the water rights on the Tuolumne River; however, in the operation studies, the rights of downstream interests were considered. Downstream interests include the Modesto, Turlock, and Waterford Irrigation Districts and the City and County of San Francisco.

An agreement dated December 2, 1963 between Tuolumne County Water District No. 2, the City and County of San Francisco, and Modesto and Turlock Irrigation Districts contains certain provisions regarding water rights applications and stipulations regarding the operation of reservoirs proposed by Tuolumne County Water District No. 2. The most important provision regarding future projects in Tuolumne County states that the downstream interests will not oppose future applications to appropriate water by the County of Tuolumne for any project in Tuolumne County involving domestic uses and essentially nonconsumptive uses such as recreation and fish and wildlife enhancement, provided that the proposed project is feasible and the County is willing to agree to an operation criteria similar to that appended to the December 2, 1963 agreement.

Provisions in the operating criteria referred to that would most affect the operation of reservoirs in Southern Tuolumne County are essentially as follows:

1. When the forecasted natural April through July runoff of Tuolumne River at La Grange is less than 1,000,000 acre-feet (hereinafter referred to as "dry years"), depletions in streamflow for the period from October 1 of each year to September 30 of the succeeding year shall not exceed streamflow accretions during the same period. (Streamflow depletions are caused by storage increases, consumptive use, and evaporation. Streamflow accretions are derived from reservoir releases in excess of the natural flow which would have occurred at the damsite.)

2. During dry years, sufficient releases from storage shall be made in advance of September 1 so that with normal releases only during September the streamflow depletions for the previous 12-month period shall not exceed the streamflow accretions.

3. When the forecasted natural April through July runoff of Tuolumne River at La Grange is more than 1,000,000 acre-feet (hereinafter referred to as "normal or wet years"), no depletions are allowed at any time when the computed natural flow at La Grange drops below 2,516 cubic feet per second.

In addition to the above provisions, a limit of 5,000 acre-feet was put on the amount of annual use in the case of Tuolumne County Water District No. 2. This latter provision and other provisions in the operating criteria probably would not seriously affect the proposed operation of reservoirs.

Provision 1, however, would seriously affect the proposed operation of reservoirs. Water could be stored temporarily during dry years but would have to be released prior to September 30 in order that streamflow accretions would balance depletions. In effect, during dry years, domestic demands and reservoir evaporation would have to be supplied by withdrawals of water stored during previous years. During the 40-year historical period 1926-27 through 1965-66, there was one period of four consecutive dry years and one of three consecutive dry years. To meet this provision it is necessary to provide active storage equal to approximately four times annual domestic demands and evaporation during the dry period. Sixteen of the 40 years were dry, or 40 percent of the years were dry and 60 percent were normal or wet.

Provision 2 limits the releases in September of dry years to "normal releases". (The rate of flow for a normal release is not defined.) The purpose of this provision is to prevent excessive releases in September for the purpose of balancing prior streamflow depletions. With recreation a primary project purpose, it is desirable to hold reservoir water surface levels as constant as possible during the recreation season; releases made in July and August would draw from storage and would be detrimental to recreation.

Provision 3 limits the duration of time when depletions could occur during normal and wet years. In a normal year such as 1962, there would be a period of about six months when storage could not be increased and consumptive use and evaporation losses would be supplied from storage withdrawals.

The December 1963 agreement previously referred to stated that future projects in Tuolumne County would not be opposed by downstream interests if reservoirs were operated according to "similar" criteria. In the case of possible reservoirs in Southern Tuolumne County, the criteria would have to be modified because of the differences of factors involved.

Almost all of the runoff at the Shanahan Flat damsite is from rainfall which occurs prior to April 1. The forecasted April through July runoff at Tuolumne River at La Grange (Provision 1) could not be used in determining storage operation. Water would have to be stored at the time of inflow, and subsequent adjustments could be made by releases from storage. This modification would affect Provision 3 also. At the time of runoff into the proposed Shanahan Flat Reservoir it would not always be apparent whether or not the natural flow of Tuolumne River at La Grange were in excess of 2,516 cubic feet per second.

In regard to Provision 2, the proposed reservoirs and consumptive use in Southern Tuolumne County are so small that this provision was not considered to apply. Releases necessary to make streamflow accretions balance depletions in dry years would all be made in September. With demands estimated to occur in the year 2005, approximately 1,200 acre-feet would have to be released in September after a single dry year. This would amount to a continuous rate of only about 20 cubic feet per second, which could be considered as a "normal release". After four consecutive dry years, with year 2005 demands, about 3,800 acre-feet would have to be released in September of the fourth dry year. This is equivalent to a continuous flow of 64 cubic feet per second. These small flows would have a negligible effect on New Don Pedro Reservoir operation. Year 2005 was cited in the example because it represents the approximate midpoint of the 50-year project life.

The following criteria in regard to water rights were used in operation studies:

1. Dry years would be determined by the computed natural flow of the Tuolumne River at La Grange. If the April through July runoff is less than 1,000,000 acre-feet, the year would be designated as dry.

2. Proposed reservoirs would be able to store inflow from winter and spring rainfall runoff. Adjustments for over-storage could be made by releases at a later date.

3. Releases necessary to make dry year streamflow accretions balance depletions would be made at a constant rate during September of the dry year.

4. During dry years, streamflow depletions caused by one reservoir could be balanced by streamflow accretions from another reservoir.

5. During normal and wet years, operation of proposed reservoirs would be deemed as not causing any interference with downstream interests.

The above operating criteria are not intended to be an interpretation of water rights. An operating agreement between sponsors of a proposed project and the downstream interests would be necessary before the project could be constructed. The criteria are similar to that of the December 1963 agreement between Tuolumne County Water District No. 2 and the downstream interests, with necessary modifications included to make proposed operations workable.

Net Evaporation. Net evaporation losses from the reservoirs were used in the operation studies for this investigation. Net evaporation is the evaporation from reservoirs less the evapotranspiration from the reservoir sites which would occur if the reservoirs were not constructed.

The procedure of computing net evaporation for each reservoir is presented in Chapter IV, "Proposed Projects".

Recreation Reservoir Sites

The three reservoir sites considered in the preliminary edition of Bulletin No. 96 (Harden Flat, Burch Meadow and Groveland) were re-evaluated. Additional sites were also selected and studied, making use of available topographic maps and aerial photographs in conjunction with field reconnaissance.

Although the Harden Flat and Groveland Reservoir sites have the best potentials for providing large amounts of storage, there is a scarcity of lands surrounding the sites suitable for recreation development. At Harden Flat, a reservoir with an area of 86 acres and a capacity of 1,830 acre-feet would inundate almost all lands suitable for recreation development. The Groveland site has the disadvantages of having little tree cover and relatively steeply sloping lands surrounding the proposed reservoir. There is a small area to the north of the reservoir site suitable for recreation development.

The Burch Meadow site offers an attractive setting, is located adjacent to Highway 120, and has a large amount of surrounding land suitable for development. It has disadvantages, however. Geologic studies indicate that the north half of the reservoir site is underlain by pervious tertiary gravels which extend into the Kassabaum Meadow area to the north. Reservoir leakage could present a serious problem. It was beyond the scope of this investigation to conduct extensive geologic studies necessary to estimate the amount of leakage and determine whether an economical method could be found to reduce leakage. Another disadvantage is that water would have to be imported to Burch Meadow Reservoir for initial filling and maintenance of a full reservoir because the 2.4 square mile watershed tributary to the reservoir has an estimated mean annual runoff of only 900 acre-feet. During the 4-year drought period from 1928 through 1931 the estimated average annual runoff was only 240 acre-feet. The Middle and South Forks of the Tuolumne River offer the most economical sources of water for export to Burch Meadow. Facilities required would include approximately five miles of pipeline and a pump which would lift the water about 500 feet.

Two additional reservoir sites in Southern Tuolumne County were found which were worthy of consideration. These were the Stone Meadow site on an unnamed tributary to the Middle Fork of the Tuolumne River about two miles south of Mather and the Shanahan Flat site on Big Creek about one mile west of Smith Station.

The Stone Meadow site appears to offer the greatest recreation potential of any reservoir site in Southern Tuolumne County. Good access is provided by about 3 miles of paved road from Highway 120. The reservoir is at an ideal elevation of 4,500 feet; the hot, dry climate of the lower elevation is avoided as well as the chilling nighttime temperatures of higher elevations. Surrounding the reservoir site is a moderate to dense coniferous forest, which would provide the camper with shade and seclusion. Over 300 acres of land with slopes of 20 percent or less are adjacent to the reservoir site and would provide an excellent location for recreation facilities.

The Shanahan Flat site was selected as an alternative to the Burch Meadow site. Although the amount of developable land surrounding the reservoir site is not as great as for Burch Meadow, it does not have the disadvantages of Burch Meadow previously mentioned. Reservoir leakage is not anticipated, and an import of water from the Middle or South Fork of the Tuolumne River would not be necessary until far into the future. The mean annual runoff from the 7.8-square-mile watershed tributary to the reservoir was estimated to be 2,950 acre-feet.

Shanahan Flat Reservoir would be located about one-fourth mile from Highway 120. The young coniferous forest surrounding the reservoir would provide natural beauty and shade for the recreationist. Several small valleys along streams tributary to the reservoir provide secluded areas for camping. Shanahan Flat Reservoir would extend upstream almost to Burch Meadow, and the picturesque Burch Meadow could be available for development in conjunction with the Shanahan Flat development.

Fish Enhancement Possibilities

Fish enhancement benefits would accrue primarily to reservoirs. Four reservoir sites were evaluated by the California Department of Fish and Game: Stone Meadow, Burch Meadow, Shanahan Flat, and Groveland. The Stone Meadow site was considered as suitable for a cold-water trout fishery; the others would be predominantly warm-water fisheries.

Consideration was given to the possibility of enhancing stream fisheries by releasing water from the proposed Stone Meadow Reservoir to augment the late summer and autumn low flows of the Middle and South Forks of the Tuolumne River. An evaluation revealed that reservoir drawdown caused by such releases would result in more detriment to recreation and the reservoir fishery benefits than would be gained from stream fisheries enhancement benefits.

A brief evaluation was made of the possibility of maintaining a year-round live stream to provide a fishery on Big Creek. Because of the limited natural runoff of Big Creek and the expense of importing water from the Middle or South Forks of the Tuolumne River, this possibility was found to be infeasible.

The evaluation of reservoir fisheries is presented in Chapter V, "Economic Considerations".

Alternative Sources of Domestic Water Supply

Alternative sources considered as possible means of meeting domestic water supply demands included (1) increased development of ground water, (2) diversion from the Hetch Hetchy Aqueduct, (3) direct diversion from perennial streams, and (4) storage reservoirs on Big Creek.

Increased Development of Ground Water. As was explained in Chapter II, the only water bearing rocks having a possibility for development of an area-wide water supply are the tertiary gravels near Smith Station. Insufficient data are available on the volume of storage available and on the natural recharge characteristics of these gravels to make a reliable estimate of the ground water yield.

A report titled "Feasibility Report, Groveland Use of Hetch Hetchy Water" by Darrhl Dentoni, Consulting Engineer for Groveland Community Services District, concluded that although wells in the tertiary gravels could be termed good, they do not produce flows large enough for the anticipated growth of the area. The report also concluded that the Hetch Hetchy Aqueduct was a preferable source of supply.

Diversion from Hetch Hetchy Aqueduct. Diversion from the Hetch Hetchy Aqueduct at the Second Garrotte Shaft provides the water supply for the community of Groveland. The water is of unquestioned high quality, requiring only chlorination as treatment. This source has the advantage of having the least initial cost of all the alternative sources. It has a disadvantage that continuing water costs are high. At the present rate of use, water charges by the City of San Francisco Public Utilities Commission amount to about $100 per acre-foot and pumping costs to lift the water approximately 960 feet amount to about $30 per acre-foot.

Direct Diversion from Perennial Streams. Brief estimates were made of possible single-purpose alternatives to supply domestic water by diversions from the South Fork, Middle Fork, or Main Stem of the Tuolumne River. Conveyance distances to the service area and pumping heads were found to be so great as to render these sources infeasible. Furthermore, there would probably be a water rights problem because streamflows would be depleted during dry years.

Storage Reservoirs on Big Creek. Big Creek is an ephemeral stream, and storage would have to be provided to use this source for a domestic water supply. The runoff from Big Creek is sufficient to meet domestic water demands far into the future with a nominal amount of storage. There are no other ephemeral streams within the area with runoff sufficient to be considered for an area-wide water supply. A multiple-purpose reservoir could also include recreation and fish enhancement with costs allocated to these purposes reducing the costs allocated to domestic water supply.

Analyses of water samples taken from Big Creek indicate that the water is of excellent mineral quality, however, the water would require treatment in addition to chlorination before it could be used as a domestic supply.

Project Selection

Many alternatives were considered in formulating a plan to develop the water resources of Southern Tuolumne County for recreation, fish enhancement, and domestic water supply. Some alternatives were eliminated after brief appraisal; others required detailed estimates of costs and benefits to devise the best plan.

Alternative plans for conveying water from the Middle and South Forks of the Tuolumne River to the headwaters of Big Creek were evaluated. Among plans considered were (1) diversions at Harden Flat and conveyance along the alignment of the abandoned Golden Rock Ditch, (2) pumping from the Middle or South Forks of the Tuolumne River and conveyance to Big Creek, and (3) lifting water by a turbine-pump unit. The turbine-pump unit, located downstream from the Highway 120 bridge over the South Fork, would receive water through a pipeline diversion from the Middle Fork, and pump a portion of the diversion through a pipeline to the Big Creek basin. Alternative conduit types included pipelines, lined and unlined canals, and bench flumes. The turbine-pump scheme provided the most economical means to import water to Big Creek.

Five possible reservoir sites were evaluated: Stone Meadow, Harden Flat, Burch Meadow, Shanahan Flat, and Groveland. The Harden Flat and Groveland reservoir sites proved to have the least potential for recreation because of the lack of developable lands for recreation. The Stone Meadow site has the greatest recreation and fish enhancement potential.

Whether to recommend Burch Meadow or Shanahan Flat Reservoir as a project feature was a difficult decision. The Burch Meadow site was considered by the California Department of Parks and Recreation to be superior to the Shanahan Flat Site, although both sites have good potential as recreation reservoirs. Project costs, however, would be much higher with Burch Meadow Reservoir as a project feature. The dam and reservoir would be more expensive, and an estimated additional initial capital expenditure of $802,000 to import water would be required. Furthermore, the problem of reservoir leakage at Burch Meadow could not be resolved.

In comparing benefits and costs, the Shanahan Flat Reservoir had a slightly greater benefit-cost ratio. Indirect benefits, although not evaluated in monetary terms, favor Shanahan Flat. The Shanahan Flat Site is not particularly suited for any type development other than a recreation reservoir, whereas the Burch Meadow site, adjacent to Highway 120, is an attractive area suitable for residential homesites, a golf course, or other uses.

In summary it was found that (1) net benefits of Burch Meadow and Shanahan Flat Projects would be nearly equal, (2) the Burch Meadow Project would be considerably more expensive, (3) the Burch Meadow Project would preclude more alternative benefits, and (4) a serious problem of reservoir leakage might occur at Burch Meadow. Based on the above, the Shanahan Flat Project was selected as a project feature. There was little question but that Stone Meadow Reservoir should be selected because it was (1) found to have the best recreation and fish enhancement potential, and (2) well suited as a supplemental source of future water supply.

CHAPTER IV. PROPOSED PROJECTS

This chapter contains descriptions and design considerations of the physical features of the proposed projects. Proposed physical features include (1) Stone Meadow and Shanahan Flat Dams and Reservoirs, (2) associated recreation facilities at each site, (3) two diversion dams and associated conduits and appurtenent works, (4) a pumping plant and pipeline to convey water to the project service area, and (5) water treatment facilities. Plate 3 (page 35) presents a plan of the proposed development.

Stone Meadow Project

The Stone Meadow Reservoir site is located about two miles south of Mather on an unnamed tributary to the Middle Fork of the Tuolumne River. Access to the site is provided by about three miles of paved road from Highway 120 near Carlon Guard Station. The proposed dam would be located on the east line of Section 15, Township 1 South, Range 19 East, MDB and M. Streambed elevation at the damsite is 4,420 feet. Portions of Section 15, 16, 22 and 23, Township 1 South, Range 19 East would be inundated by the reservoir. A diversion from the Middle Fork would provide supplemental inflow for Stone Meadow Reservoir. The general features of the proposed Stone Meadow Dam and Reservoir and Mather Diversion are shown in Table 10[1/].

Design Considerations

Aerial photographs of the dam and reservoir site were taken in August of 1966 and a topographic map of the dam and reservoir area was prepared at a scale of one inch equals 400 feet with a contour interval of ten feet. The topographic mapping was used to determine the location of the damsite axis, spillway, and outlet works; to determine stripping and embankment quantities; and to determine the elevation-area-capacity characteristics of the proposed reservoir.

The axis of the damsite is in a wide V-shaped streambed which provides drainage from Stone Meadow. The gently sloping abutments are mantled by decomposed granite with occasional outcroppings of residual boulders and unweathered granitic rock. The granitic bedrock exposures along the channel section are discontinuous and covered locally with sand and gravel deposits and colluvial boulders. The unweathered granitic rock is hard, massive, and moderately jointed at the surface.

The decomposed granite that mantles the abutments is soft and friable at the surface but becomes firm with depth as unweathered bedrock is reached. The depth of the decomposed granite is variable and is estimated to range from zero to 20 feet on the abutments. An estimated average depth of 5 feet would be required for abutment stripping and a depth of 15 feet would be required for the cut-off trench. Grouting requirements are expected to be light.

The reservoir area would occupy Stone Meadow, a flat elongated meadow bounded by gently sloping peripheral edges. The reservoir site is

1/ Tables are placed at the end of the chapter.

underlain by granitic rock terrain. Leakage from the reservoir is not expected, and landsliding potential is virtually nonexistent.

The alluvial fill in Stone Meadow and the large volumes of decomposed granite nearby would serve as potential impervious earthfill materials. Pervious materials for rockfill, rip-rap, and filter drains could be provided by developing a quarry on the south slope of Ascension Mountain or Sawmill Mountain.

To determine the spillway capacity, the probable maximum flood inflow was routed through the reservoir. Because of the small circular watershed area (3.15 square miles), a 6-hour storm duration produced the most critical flood. The peak inflow was estimated at 10,600 cubic feet per second, and the 6-hour runoff volume was estimated at 1,900 acre-feet.

Dam

Based upon geologic and topographic considerations, a modified homogeneous earthfill dam was found to be the most economical of several engineeringly feasible types. The height of the dam would be 115 feet at the maximum section, the crest length 1,080 feet, and the crest width 30 feet. The upstream slope would be 3:1 and the downstream slope 2:1. Figure 1 presents a plan view, a profile along the axis of the dam, and a cross section of theproposed dam.

Reservoir

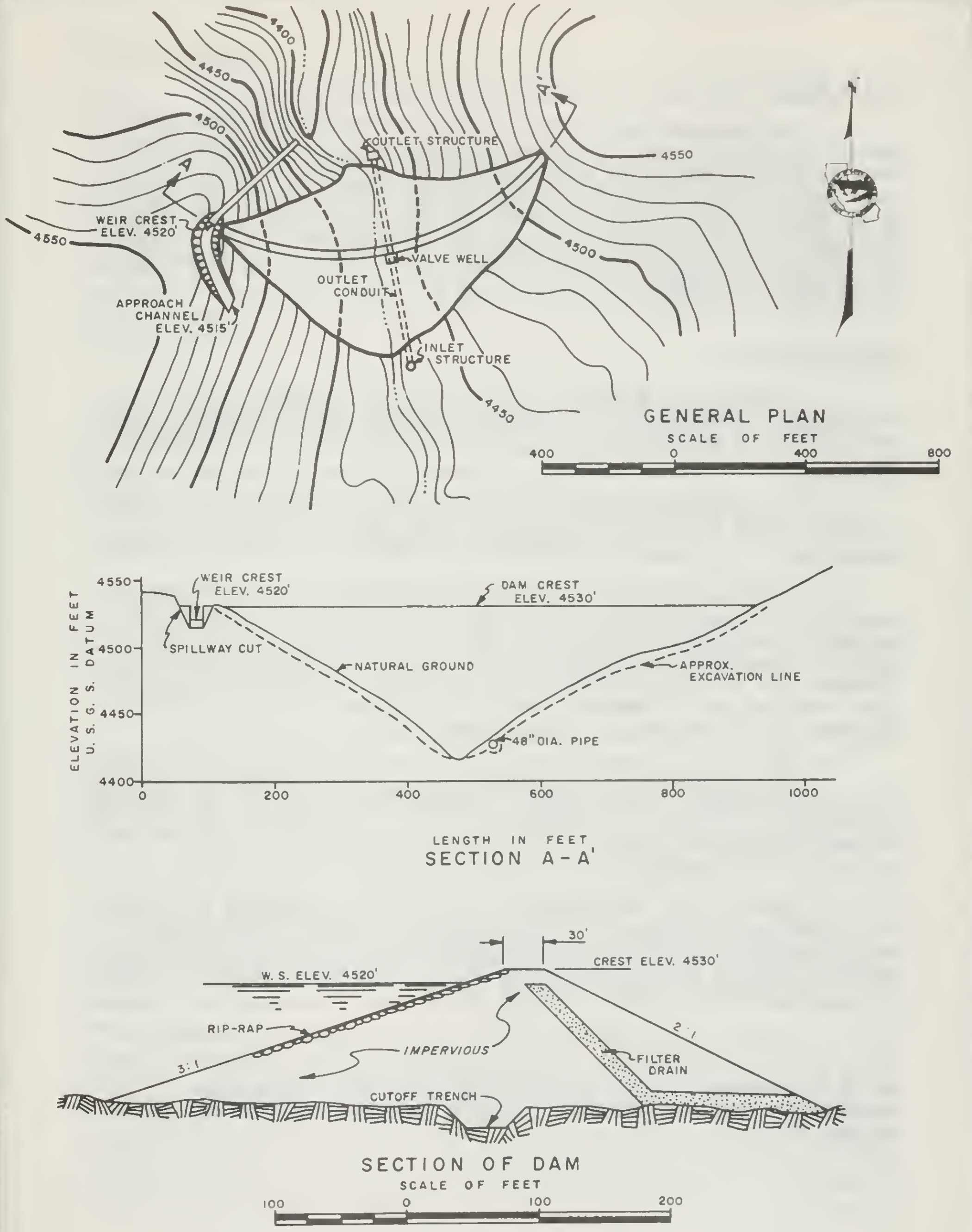
The proposed reservoir would inundate a flat, elongated meadow and gently sloping lands surrounding the meadow. The forested lands to be inundated which surround the meadow would have to be cleared.

The proposed reservoir would have a capacity of 8,500 acre-feet and a surface area of 231 acres at a normal pool elevation of 4,520 feet. The elevation-capacity-area relationships of the proposed reservoir as shown in Table 11.

Spillway

The spillway would be of a chute type and would be located on the left abutment. Although no natural re-entry to the stream can be used, a sharp bend in the stream below the dam would reduce the length of the chute. The spillway wingwalls, weir, transition, and chute would be founded on firm, weathered granitic rock and would be of concrete construction.

The estimated peak flow from the probable maximum flood would be reduced from 10,600 to 1,520 cubic feet per second by routing through the reservoir.



STONE MEADOW DAM
ON UNNAMED TRIBUTARY TO MIDDLE FORK
TUOLUMNE RIVER

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Outlet Works

The proposed outlet works would be of the cut-and-cover type founded in the right side of the channel section in unweathered granitic rock. A 48-inch steel pipe encased in reinforced concrete would convey water from the inlet structure in the reservoir to an outlet structure in the stream channel downstream from the dam. Two 36-inch gate valves to control releases would be in a dry well located near the axis of the dam. Access to the well would be provided by a vertical shaft extending to the crest of the dam.

Mather Diversion

Diversion of Middle Fork flows would be necessary for initial filling and maintaining a full reservoir at Stone Meadow because of the small amount of runoff from the 3.15 square mile watershed above Stone Meadow.

The proposed diversion dam would be located on the Middle Fork of the Tuolumne River about one mile upstream from the Middle Fork Campground. The streambed elevation at the damsite is about 4,620 feet.

The cross section of the Middle Fork channel at the diversion damsite is V-shaped with side slopes of about 30 percent. A surficial geologic investigation revealed that much of the channel section is exposed, unweathered granitic rock with residual boulders, and the abutments are covered with weathered granitic rock. Foundation preparation would consist of removal of the weathered granitic rock on the abutments and minor shaping of the channel section.

The proposed diversion dam would be a concrete gravity structure with an ogee-shaped overpour crest. Water stored behind the dam would not constitute a flood threat, therefore the dam was designed to pass a flood having a recurrence interval of 100 years with one foot of freeboard below the top of the wingwalls.

Outlets from the dam would be provided to discharge flows into the stream below the dam and into a pipeline to convey water to Stone Meadow Reservoir. Slide gates would regulate the flows. The reinforced-concrete pipeline from the diversion dam to Stone Meadow Reservoir would have a capacity of 25 cubic feet per second.

Under the proposed operation of the diversion, a minimum flow of 40 cubic feet per second or the entire natural flow, whichever is less, would be maintained below the dam except in extremely dry years when the minimum flow would be reduced to 20 cubic feet per second or the entire natural flow.

Proposed Operation

Stone Meadow Reservoir would be operated under the criteria discussed in Chapter III.

Under the proposed operation, dry-year streamflow depletions from evaporation and consumptive use of water from both Stone Meadow Reservoir and Shanahan Flat Reservoir would be balanced by streamflow accretions from Stone Meadow Reservoir. This would enable both reservoirs to remain almost full during the recreation season in all except extremely dry years such as 1930-31 and 1960-61. Tables 28 through 30 of Appendix B present the proposed operation of Stone Meadow Reservoir under conditions of water supply which occurred during the 40-year period from 1926-27 through 1965-66.

Inflow. Inflow to Stone Meadow Reservoir would be from the natural runoff of the watershed tributary to the reservoir and from the Mather Diversion. Estimates of the natural inflow and the flow at the Mather Diversion were made by correlations of the Middle Fork of Tuolumne River at Oakland Recreation Camp and near Mather. See Tables 3 and 4 of Chapter II. Inflow to Stone Meadow Reservoir from the Mather Diversion is shown in Column 8 of Table 28 in Appendix B.

The average annual natural runoff at the Stone Meadow damsite for the 50-year period 1916-17 through 1965-66 was estimated to be 1,790 acre-feet. The estimated annual runoff varied from a maximum in 1937-38 of 6,670 acre-feet to a minimum of 625 acre-feet in 1930-31. The estimated inflow from the watershed tributary to the proposed reservoir is presented in Column 7 of Table 28 in Appendix B.

The estimated annual natural runoff at Mather Diversion for the 50-year period 1916-17 through 1965-66 was estimated to be 39,000 acre-feet. The estimated annual runoff varied from a maximum of 100,600 acre-feet in 1937-38 to a minimum of 9,440 acre-feet in 1930-31.

The proposed Mather Diversion, which would have a capacity of 25 cubic feet per second, would divert an average of about 10 percent of the flow at this point. Most of this diversion would return to the Middle Fork through releases from Stone Meadow Reservoir. Estimates of the amount of water which could be diverted were based on diversion capacity and estimated daily flows at the diversion dam. As previously mentioned, a minimum of 40 cubic feet per second would be left in the stream in all but extremely dry years when the minimum would be reduced to 20 cubic feet per second.

Evaporation. In computing evaporation losses the concept of "net evaporation" was used. Net evaporation is the difference between the evaporation from the reservoir water surface and the evapotranspiration which would have occurred from the area that the reservoir occupies if the reservoir were not constructed. This difference represents the increased water loss due to the reservoir.

There are several ways to compute net evaporation; however, the following method appears to be the simplest and most direct: Net evaporation equals the evaporation from the reservoir water surface minus the rainfall on the reservoir water surface plus the runoff which would have occurred from the reservoir area if the reservoir were not constructed.

The estimated annual evaporation and monthly distribution of evaporation at Stone Meadow Reservoir was based upon studies of similar reservoirs in the Sierra Nevada. The annual reservoir water surface evaporation rate was estimated to be 3.6 feet. Precipitation on the proposed reservoir was estimated by extension of records at the Mather Station.

Releases. Under the proposed operation, the natural inflow plus the diversion would be greater than the reservoir evaporation losses and compulsory releases in all but extremely dry years. The average annual inflow to the 8,500 acre-foot reservoir would be about 5,500 acre-feet, or approximately 65 percent of the reservoir capacity. By maintaining this inflow, no stagnation or algae problems should be encountered. The small amount of drawdown that would occur during almost all years would be replaced during the early part of the spring snowmelt runoff, and subsequent inflow to the reservoir would be released immediately.

In addition to the usual releases above, releases would have to be made in September of "dry years" in order that streamflow accretions would balance the previous 12-month streamflow depletions.

Proposed streamflow releases and September dry year releases are shown in Columns 11 and 12, respectively, of Tables 28, 29, and 30 of Appendix B.

Estimates of future water demands indicate that Shanahan Flat Reservoir could not meet the demands after year 2005 and that an import of water would be required. It is proposed that this demand be met by releases from Stone Meadow. The estimated amount of water to be released for export under the year 2025 domestic demands is shown in Table 30 of Appendix B.

Recreation Potential

The location, climate, topography, vegetative cover, and natural beauty would combine to assure an excellent setting for recreation facilities at Stone Meadow.

Because of its proximity to Yosemite National Park, many visitors would make this their base camp while visiting the park. Others would use camping facilities here while hunting in the Stanislaus National Forest or fishing in the streams and rivers nearby. Others would camp at Stone Meadow Reservoir because of the pleasant summer nighttime temperatures, the trout fishing, the swimming, horseback riding in the beautiful scenic surroundings, or a combination of these.

Day use of the facilities would be from highway travelers, residents of summer homes, and organizations camping nearby without water-associated recreation facilities.

The vegetation at the site is a heavy coniferous forest of large, mature pines scattered throughout dense stands of younger trees. The area to be inundated consists of meadow lands and scattered pine trees. Some of the meadow lands extend above the proposed water surface elevation and would make an attractive shoreline.

There is an almost unlimited amount of gently sloping land surrounding the reservoir site which is suitable for onshore recreation facilities. Slopes range from 5 to 25 percent, with most in the 10 to 15 percent range.

On Figure 2, the areas most suitable for recreation development are delineated. The areas were determined from topographic maps, aerial photographs, and field reconnaissance. Day use areas would be located close to the reservoir. The gently sloping shoreline surrounding most of the reservoir would offer an excellent location for swimming beaches.

There is adequate land available to provide three large camping areas without crowding. Two camp areas could be located on the eastern shore and one near an area on the western shore.

Initial development would occupy only a small portion of the total developable land, estimated at over 300 acres, shown on Figure 2. The initial development is proposed at the most favorable location. It is beyond the scope of this investigation to present in detail the location and staging of the development of recreation facilities.

Fish Enhancement Potential

Stone Meadow Reservoir will be a cold-water-trout producing reservoir. Although the surface layer of the reservoir will become warm in the summer, the inflows, which are derived almost entirely from snowmelt runoff, will make the average water temperature cold.

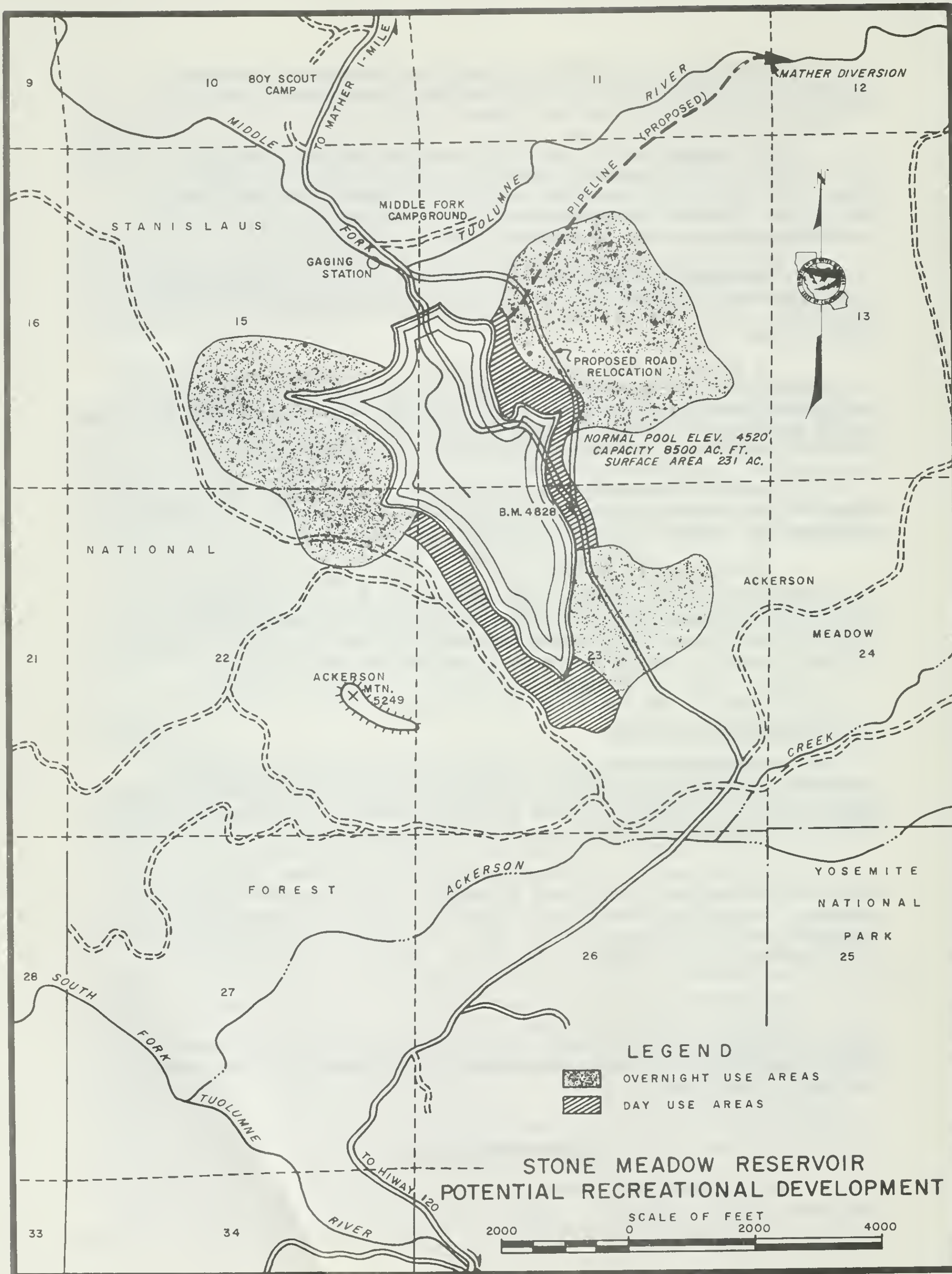
A study made by the Department of Fish and Game indicated that Stone Meadow Reservoir will yield 25 pounds of trout per acre annually to anglers. Fingerling rainbow trout would be planted each year by the Department at an estimated cost of $915. The reservoir could sustain a use of 11,250 angler days annually, based upon anticipated fish production.

The Mather Diversion Dam would slightly enhance the trout productivity in the small reservoir formed, however, a slight loss in productivity would occur below the dam, which would be a barrier to the movement of the fish. Essentially no loss to the Middle Fork fishery would be caused by the Mather Diversion.

Shanahan Flat Project

The Shanahan Flat Reservoir site is located on Big Creek about one mile west of Smith Station. Access to the site is provided by about one-half mile of paved road from Highway 120. The proposed dam would be located

FIGURE 2



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in the northwest quarter of Section 32, Township 1 South, Range 17 East, MDB and M. Streambed elevation at the damsite is 2,860 feet. The reservoir would lie almost entirely in Section 32, Township 1 South, Range 17 East, with a small portion of one arm lying in Section 31. The general features of the proposed Shanahan Flat Dam and Reservoir are shown in Table 12.

Design Considerations

The best topographic mapping available of the dam and reservoir site is the $7\frac{1}{2}$ minute USGS Groveland quadrangle. An enlargement of this map was used to determine the location of the damsite axis, spillway, outlet works, stripping and embankment quantities and the elevation-area-capacity characteristics of the proposed reservoir.

At the damsite the stream channel section is partially covered by a thin alluvial fill deposit consisting of sand, gravel and boulders. The exposed bedrock along the channel is a gray-black recemented brecciated schist which is very hard, durable, and moderately fractured. Stripping in the channel section would require removal of the shallow alluvial fill and shaping of the irregular bedrock surface.

The abutments of the damsite are mantled by reddish-brown weathered schist which is soft and friable. The depth of weathering is expected to be variable, and the intensity of weathering is expected to decrease with depth below the surface. Stripping depth on the abutments is estimated to average about five feet normal to the slope, and the cutoff trench required to reach unweathered bedrock is estimated to average 15 feet in depth. Grouting requirements are expected to be light.

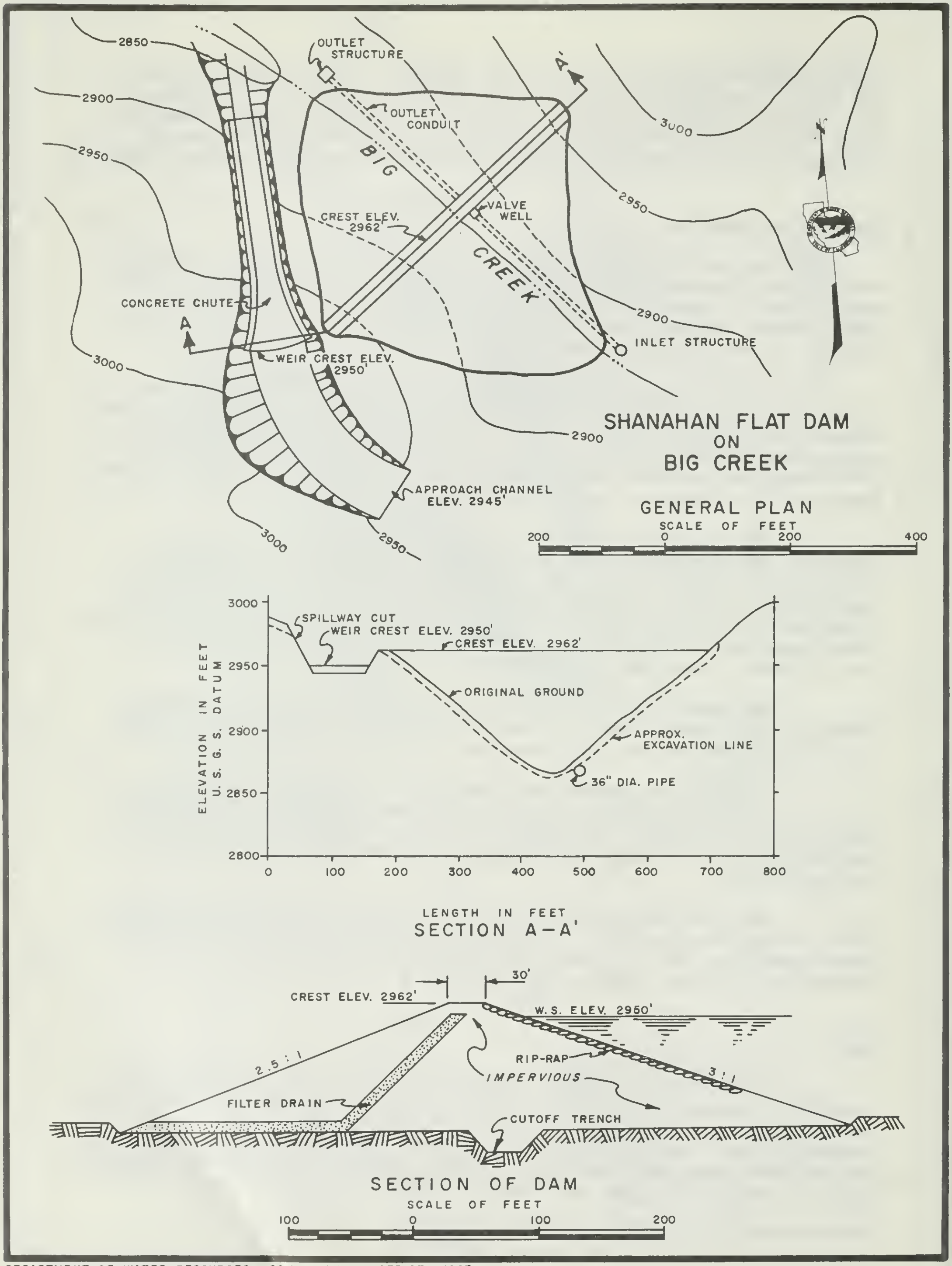
The reservoir site lies within an area underlain by metamorphic rocks of the Calaveras Group. Reservoir leakage is expected to be negligible, and siltation and landslides are not expected to be problems.

Impervious materials for construction of the earth embankment occur in the form of deeply weathered Calaveras metamorphic rocks in substantial quantities near the damsite. Pervious materials for filter drains and rip-rap occur in local outcroppings of metamorphic rocks of the Calaveras Group.

Spillway capacity was estimated by routing the probable maximum flood through the reservoir. The probable maximum flood had an estimated peak inflow from the 7.8 square mile watershed of 13,200 cubic feet per second and a 24-hour runoff volume of 7,200 acre-feet.

Dam

Based upon geologic, topographic, and economic considerations, a modified homogeneous earthfill type dam was selected for this site. The height of the dam would be 102 feet at the maximum section, the crest length 500 feet, and the crest width 30 feet. The upstream slope would be 3:1 and the downstream slope 2.5:1. Figure 3 presents a plan view, profile along the axis of the dam, and cross-section of the proposed dam.



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Reservoir

The proposed reservoir would inundate a valley approximately one mile long and would have several arms where tributary streams enter the site. The reservoir site is covered with a moderate to dense stand of young coniferous forest with some oak trees and brushland intermingled.

The proposed reservoir would have an area of 129 acres capacity of 3,920 acre-feet at normal pool elevation. The elevation-capacity-area relationships of the proposed reservoir is shown in Table 11.

Spillway

Consideration was given to both side-channel and chute-type spillways. Although the side-channel type would require less excavation, it would be more expensive because of a greater amount of structural concrete.

The chute spillway would be located on the left abutment. An approach channel with a bottom width of 100 feet, side slopes of 1:1, and a length of 250 feet would convey flood flows from the reservoir to the spillway. The flows would then pass over a concrete ogee-shaped weir, enter a chute, and be discharged into the stream channel below the dam. The spillway weir, transition, and chute would be founded on firm, weathered metamorphic rock and would be constructed of reinforced concrete.

The estimated peak inflow from the probable maximum flood would be reduced from 13,200 cubic feet per second to 11,300 cubic feet per second by routing through the reservoir.

Outlet Works

The proposed outlet works would be the cut-and-cover type founded in the right side of the channel section in unweathered metamorphic rock. A 36-inch steel pipe encased in reinforced concrete would convey water from the inlet structure in the reservoir to an outlet structure in the stream channel downstream from the dam. Two 30-inch gate valves to control releases would be placed in a dry well near the axis of the dam. Access to the well would be provided by a vertical shaft extending to the crest of the dam.

Water Treatment Facilities

Because of the relatively small capacity required to meet domestic demand, a "package type" water treatment plant was found to be the most economical. With this type of plant, component parts are shop-fabricated and delivered to the job site for installation. Future expansion can easily be accomplished by adding additional units.

Complete treatment would probably be required of water to be used for domestic use from Shanahan Flat Reservoir. The treatment would include coagulation and sedimentation, filtration, and chlorination.

The proposed initial (year 1975) facilities would have a capacity of 280 gallons per minute. Component parts would include an inlet control, dry chemical feed, precipitator, filter, hypochlorinator, and treated water storage tank. In 1985 the capacity could be increased to 560 gallons per minute by addition of one filter of the same capacity as the initial filter. Further expansion would be accomplished by the addition of units of the same capacity as the initial unit. A unit of this size is specified because it is about the largest unit that can be shop-fabricated and delivered to the jobsite. Larger units would have to be field-fabricated which would result in increased costs.

The proposed treatment plant would be located on a flat area just to the west of the dam and would receive untreated water pumped from Shanahan Flat Reservoir.

Conveyance to Area of Demand

Conveyance facilities would be provided to transport treated water from Shanahan Flat Reservoir to the area of demand. Most of the service area would be higher in elevation than Shanahan Flat Reservoir and, therefore, would require a pumping lift.

As in the case of the water treatment facilities, staged development would be more economical than initial construction of facilities to meet the maximum demands during the 50-year project life.

Facilities for the proposed initial development would include a 25-horsepower pump which would receive treated water from the storage tank near Shanahan Flat Dam and pump it through 21,000 lineal feet of 10-inch asbestos-cement pipe to the approximate center of the service area (in the center of the north line of Section 27, Township 1 South, Range 16 East, MDB and M). Plate 3, page 34, shows the approximate alignment of the proposed pipeline.

Second stage development in 1985 would replace the initial 25-horsepower pump with a 50-horsepower pump, which would supply the increased demand.

Third stage development in 1995 would replace the 50-horsepower pump of the second stage with a 125-horsepower pump, which would supply the increased demand.

In the fourth stage of development in 2005 an additional pipeline paralleling the initial pipeline would be required. The pipeline would be a 12-inch asbestos-cement pipe and would have a length of 21,000 feet. The 125-horsepower pump of the third stage would be replaced with a 150-horsepower pump to supply the increased demand.

The final stage of development in 2015 would entail the replacement of 150-horsepower pump of the fourth stage with a 300-horsepower pump to supply the increased demand.

Proposed Operation

Shanahan Flat Reservoir would be operated under the criteria discussed in Chapter III.

Under the proposed operation, dry year streamflow depletions from reservoir evaporation and domestic use of water would be balanced by accretions from September releases from Stone Meadow Reservoir. This would allow dry year inflows to Shanahan Flat to be used for domestic water supply and to replace evaporation losses.

An import of water to Shanahan Flat would be required under demands estimated to occur after the year 2005. Releases of water from Stone Meadow Reservoir and rediversion and conveyance to the headwaters of Big Creek would be the source of imported water.

Tables 31 through 33 of Appendix B present the proposed operation of Shanahan Flat Reservoir under hydrologic conditions similar to those during the 40-year period 1926-27 through 1965-66.

Inflow. Inflow to Shanahan Flat Reservoir would be provided by the natural runoff from the tributary watershed (except for future proposed imports after year 2005). Estimates of the inflow to the proposed reservoir were made by correlations with the flow at the "Big Creek near Groveland" gaging station. A current meter measurement was made on April 4, 1967 of Big Creek at a point about 2,000 feet downstream from the Shanahan Flat damsite. The measurement, which was made during a period of stable flow, substantiated the correlation used.

The average annual natural runoff at the Shanahan Flat damsite for the 50-year period 1916-17 through 1965-66 was estimated to be 2,950 acre-feet. The estimated annual runoff varied from a maximum of 12,200 acre-feet in 1937-38 to a minimum of 61 acre-feet in 1930-31. Estimated dry year flows at the damsite and the estimated annual inflow to the reservoir are shown in Columns 6 and 9, respectively, of Table 31 in Appendix B.

Evaporation. Evaporation losses were computed in the same manner as for Stone Meadow Reservoir. The annual reservoir water surface evaporation rate was estimated to be 4.3 feet. Precipitation on the proposed reservoir was estimated by extensions of records at the Groveland Ranger Station.

Releases. Releases from Shanahan Flat Reservoir to the stream below the dam might be considered as spills. Unlike Stone Meadow, where inflow from snowmelt runoff can be predicted with a fair degree of accuracy, the runoff at Shanahan Flat damsite is mostly from rainfall, which is unpredictable. At all times when the reservoir is less than full, runoff would be stored to assure a full or as nearly full reservoir as possible at the end of the precipitation season.

Water for domestic supply would be pumped from the reservoir and conveyed to the service area. The annual amounts of water for this purpose are shown in Column 12 of Tables 31 through 33 of Appendix B.

Future Middle Fork Diversion to Shanahan Flat

Shanahan Flat Reservoir could not supply all of the estimated demands occurring after the year 2005 and an import of water would be required. Estimates of costs of providing this import from possible alternative sources indicate that diversion from the Middle Fork of the Tuolumne River near Oakland Recreation Camp would be the most economical. The diversion dam would be located on the Middle Fork near the east line of Section 29, Township 1 South, Range 18 East, MDB and M. Streambed elevation at the diversion damsite is 2,830 feet.

The proposed damsite is founded on granitic rock and the channel section is about 100 feet wide. Preparation of the foundation would require shaping the channel section and stripping a minor amount from the abutments.

The proposed diversion dam would be a concrete gravity structure with an ogee-shaped overpour crest. The amount of water stored behind the dam would not constitute a flood threat, therefore the dam was designed to pass a flood having a recurrence interval of 100 years with one foot of freeboard below the top of the wingwalls.

Outlets from the dam would be provided to release water to the stream below the dam and into a pipeline to convey water to a turbine-pump unit.

The Middle Fork below Oakland Recreation Camp drops abruptly to its confluence with the South Fork. This drop provides a potential source of energy which could be used to pump water to the headwaters of Big Creek. Using a hydraulic turbine as a prime mover for a pump is a unique feature of the proposed project.

A 24-inch reinforced concrete pipeline would lead from the diversion dam to point above the South Fork Canyon about 500 feet downstream from the Highway 120 bridge. From this point a 20-inch steel penstock would lead to a turbine-pump unit near the South Fork channel. The penstock would bifurcate just above the turbine-pump unit; about 80 percent of the water would flow into the "turbine" side and the remainder would flow into the "pump" side. The turbine runner would rotate the pump impeller by direct mechanical coupling. The pump would lift the 20 percent of water through the 500 feet of head required to transport the water to Big Creek. The pump penstock would cross the South Fork and climb the west side of the canyon. A 12-inch asbestos-cement pipe would then convey the water along the approximate alignment of the old Hetch Hetchy Railroad to the headwaters of Big Creek.

Table 13 presents pertinent statistical data on the proposed future diversion.

Recreation Potential

The vegetative cover of lands surrounding the Shanahan Flat reservoir site is predominantly young coniferous forest with oak trees scattered throughout.

The northeast shore of the reservoir site is generally steep with heavy tree cover. The land adjacent to the arm nearest Highway 120 is generally open with gentle slopes. Since it is close to Highway 120, it could best be used as a picnic area. The heavily wooded southeast arm has gentle slopes up to 100 feet from the shoreline. The west shore has 10 percent slopes extending to one mile inland and would provide a very suitable area for all types of onshore recreation activities. A recreation area of about 200 acres could be developed to provide most of the recreation facilities required at the reservoir.

Figure 4 presents a plan of potential development of day and overnight use areas. These areas were delineated with the aid of topographic maps, aerial photographs, and field inspection.

Camping would be a major activity, and sufficient land could be provided in the Shanahan Flat and Hells Hollow area to accommodate this function. Many visitors would use this area as a base camp while visiting Yosemite National Park or hunting and fishing in nearby areas as well as for the recreation provided at the reservoir itself. Most of the camping areas should be confined to recreation lands more than 300 feet from the shoreline which would insure adequate space for picnicking, swimming, fishing, and other day use activities.

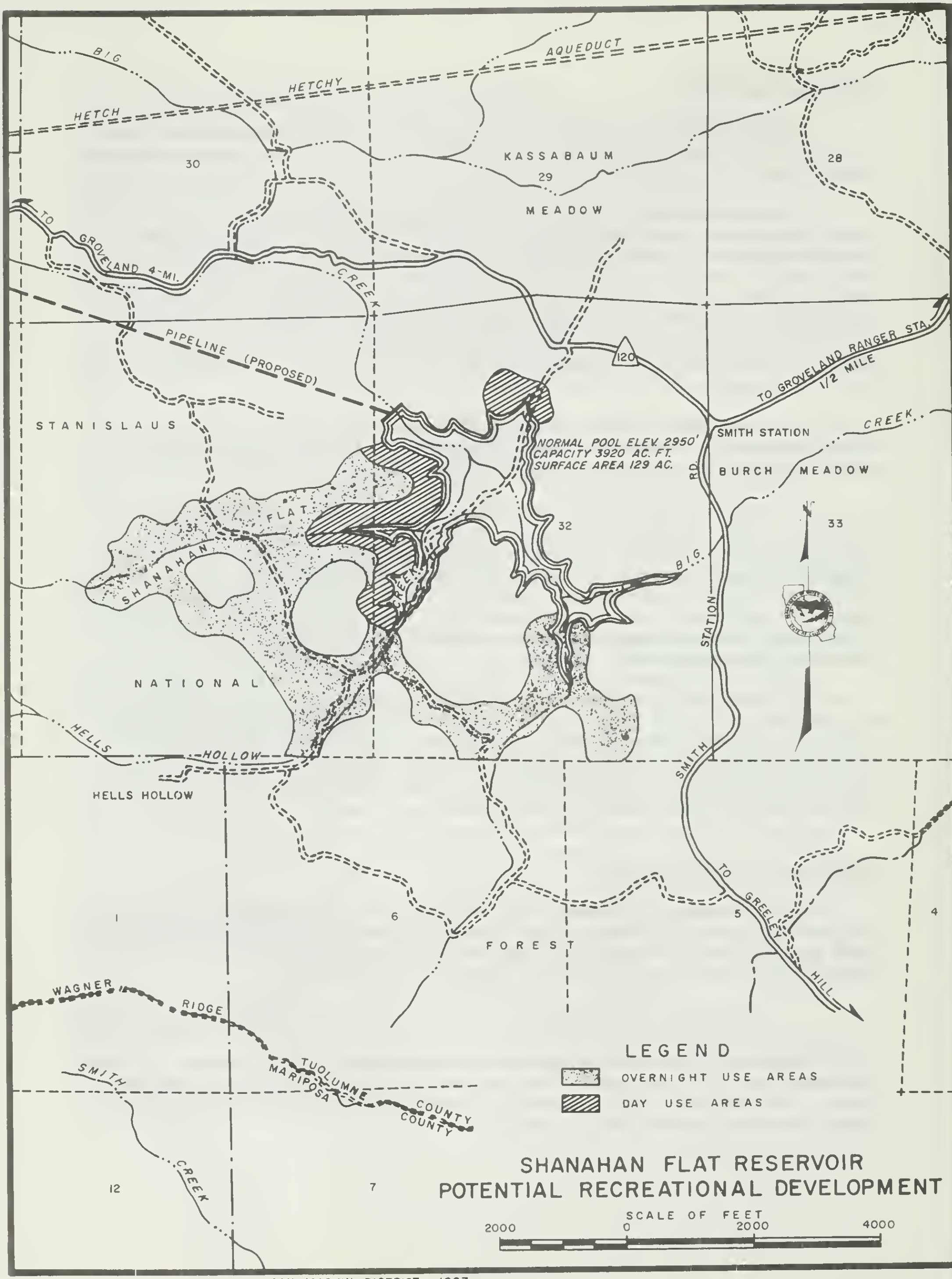
Along with camping, this reservoir should receive fairly heavy picnic use because of its proximity to Highway 120. The use of this Highway will increase each year, especially with the completion of the proposed highway realignment. Many travelers will need areas for roadside picnic and rest stops. Areas bordering lakes and streams have proven to be the most popular sites for this type of activity.

Fish Enhancement Potential

The proposed Shanahan Flat Reservoir would provide a predominantly warm-water fishery. Inflow to the reservoir would be derived almost entirely from rainfall on the watershed. The warm daytime temperatures during the summer would result in warm upper layers of the reservoir.

A study by the Department of Fish and Game indicated that the reservoir would yield 30 pounds of fish per acre annually. Initial planting cost is estimated at $4,500 including chemical treatment of the drainage to remove non-game fish. No additional stocking will be required after the initial plant. The reservoir could sustain a use of 3,260 angler-days annually, based upon anticipated fish production.

FIGURE 4



SHANAHAN FLAT RESERVOIR
POTENTIAL RECREATIONAL DEVELOPMENT

DEPARTMENT OF WATER RESOURCES SAN JOAQUIN DISTRICT 1967

TABLE 10

GENERAL FEATURES OF THE PROPOSED STONE MEADOW DAM AND RESERVOIR AND MATHER DIVERSION

Item	Description
Stone Meadow Dam	
Type	Modified homogeneous earthfill
Elevation of streambed, in feet	4,415
Crest elevation, in feet	4,530
Crest height above streambed, in feet	115
Crest length, in feet	1,080
Crest width, in feet	30
Slopes: Upstream face	3:1
Downstream face	2:1
Volume of fill, in cubic yards	457,000
Stone Meadow Spillway	
Type	Ungated chute
Crest elevation, in feet	4,520
Crest length, in feet	20
Freeboard above crest, in feet	10
Probable maximum flood peak outflow, in cubic feet per second	1,520
Stone Meadow Reservoir	
Storage capacity at minimum pool, in acre-feet	1,000
Storage capacity at normal pool, in acre-feet	8,500
Surface area at minimum pool, in acres	62
Surface area at normal pool, in acres	231
Water surface elevation at minimum pool, in feet	4,470
Water surface elevation at normal pool, in feet	4,520
Drainage area, in square miles	3.15
Mather Diversion Dam and Pipeline	
Type of dam	Concrete gravity
Type of spillway	Overflow
Type of outlet works:	
Stream outlet	24" slide gate
Conduit intake	27" slide gate
Pipeline capacity, in cubic feet per second	25
Lengths and diameters of pipeline	5,000 feet of 27-inch and 1,300 feet of 18-inch

TABLE 11

AREAS AND CAPACITIES OF PROPOSED RESERVOIRS

Water Surface Elevation, in Feet (USGS datum)	Storage Capacity, in Acre-feet	Water Surface Area, in Acres
	Stone Meadow Reservoir	
4,430	0	0
4,440	100	8
4,450	250	20
4,460	500	38
4,470	1,000	62
4,480	1,750	95
4,485	2,300	120
4,490	3,000	142
4,495	3,700	158
4,500	4,500	172
4,505	5,400	186
4,510	6,400	200
4,512	6,800	206
4,514	7,200	212
4,516	7,600	220
4,518	8,000	226
4,520	8,500	231
	Shanahan Flat Reservoir	
2,860	0	0
2,870	50	2
2,880	100	3
2,890	150	7
2,900	300	16
2,910	600	29
2,920	1,100	50
2,930	1,800	74
2,940	2,750	100
2,942	3,000	106
2,944	3,200	112
2,946	3,450	117
2,948	3,700	124
2,950	3,920	129

TABLE 12

GENERAL FEATURES OF THE PROPOSED SHANAHAN FLAT DAM AND RESERVOIR

Item	Description
Shanahan Flat Dam	
Type	Modified homogeneous earthfill
Elevation of streambed, in feet	2,855
Crest elevation, in feet	2,962
Crest height above streambed, in feet	107
Crest length, in feet	500
Crest width, in feet	30
Slopes: Upstream face	3:1
Downstream face	$2\frac{1}{2}$:1
Volume of fill, in cubic yards	232,000
Shanahan Flat Spillway	
Type	Ungated chute
Crest elevation, in feet	2,950
Crest length, in feet	100
Freeboard above crest, in feet	12
Probable maximum flood peak outflow, in cubic feet per second	11,300
Shanahan Flat Reservoir	
Storage capacity at minimum pool, in acre-feet	1,000
Storage capacity at normal pool, in acre-feet	3,920
Surface area at minimum pool, in acres	44
Surface area at normal pool, in acres	129
Water surface elevation at minimum pool, in feet	2,918
Water surface elevation at normal pool, in feet	2,950
Drainage area, in square miles	7.8

TABLE 13

GENERAL FEATURES OF THE PROPOSED MIDDLE FORK DIVERSION
TO SHANAHAN FLAT IN YEAR 2005

Item	Description
Middle Fork Diversion	
Type	Concrete gravity
Type of spillway	Overflow
Type of outlet works:	
Stream outlet	24-inch slidegate
Conduit	24-inch slidegate
Capacity of pipeline from Diversion to pump-turbine penstock, in cubic feet per second	14.0
Length and diameter of pipeline from Diversion to pump-turbine penstock	2,000 feet, and 24-inch
Length and diameter of pump-turbine penstock	500 feet, and 20-inch
Capacity of pump penstock, in cubic feet per second	2.8
Length and diameter of pump penstock	1,000 feet, and 12-inch
Length and diameter of pipeline to Big Creek	26,000 feet, and 12-inch
Design criteria for pump-turbine unit:	
Overall efficiency, in percent	72
Capacity and head on turbine side	11.2 second-feet and 200 feet
Capacity and differential head on pump side	2.8 second-feet and 590 feet

CHAPTER V. ECONOMIC CONSIDERATIONS

Estimates of the costs and accomplishments of water projects studied indicate that the two projects presented would be economically justified primarily because of the demand for water-oriented recreation facilities in this area of the State and the potential for such development. Statewide and nationwide benefits would be provided by recreation developments in this area. This is true because of the shortage of facilities for visitors from throughout the United States, and particularly from the San Francisco-Oakland Bay area. This investigation, however, was not in sufficient detail to determine the feasibility of a local agency developing either of the proposed projects at the present time. More detailed geologic and financial studies are particularly needed.

The projects as proposed would be constructed by stages. The initial stages would be completed by year 1975. Costs and benefits were estimated in terms of present worth (Year 1975) of costs and benefits occurring during the 50-year period from 1975 through 2025.

Project Costs

Preliminary design and cost estimates were made for projects presented in this report. Estimates were also made of the costs of alternative projects to assure that the projects presented are the most economical means of accomplishing the project purposes. The costs were based on prices prevailing in 1967.

Stone Meadow Project

The Stone Meadow Project consists of the (1) Stone Meadow Dam and Reservoir, (2) recreation facilities at the reservoir, and (3) the Mather Diversion and conduit from the Middle Fork to Stone Meadow. The present worth of estimated capital and annual costs of the diversion and conduit to Stone Meadow is $215,900, as shown in Table 14[1/]. The present worth of the capital and annual costs of the dam and reservoir is shown in Table 15 to be $2,268,500.

Sufficient time and personnel were not available to layout, design, and estimate the costs of recreation facilities. An estimate of unit capital cost of $9.15 per visitor-day capacity was based on estimated costs of onshore recreation facilities proposed in reconnaissance and feasibility studies of similar projects in the Sierra Nevada. The relatively high proportion of overnight to day use is reflected in this unit cost. Annual costs include operation, maintenance, and replacement of facilities. The present worth of estimated capital and annual costs of recreation facilities at Stone Meadow is shown in Table 16 to be $5,601,000.

The total present worth of the capital and annual costs shown above is $8,085,400.

1/ Tables are placed at the end of the chapter.

Shanahan Flat Project

The proposed Shanahan Flat Project consists of a dam and reservoir, recreation facilities, and water supply treatment and conveyance systems. The estimates of costs for features of the storage dam and reservoir are shown in Table 17. The capital cost of the dam and reservoir is estimated to be $1,398,710. The annual costs are estimated to be $6,900, which would have a present worth of $148,200. The capital and annual costs of typical recreation facilities for the available lands at Shanahan Flat are presented in Table 18. The capital costs are based on unit costs of $6.25 per visitor-day capacity for recreation facilities. The unit capital costs per visitor-day capacity were estimated to be less at Shanahan Flat than at Stone Meadow because of the greater percentage of day use at Shanahan Flat. Annual costs include operation, maintenance, and replacement of facilities. The present worth of capital and annual recreation facility costs is estimated to be $2,545,600.

The total costs for water supply treatment and conveyance systems include the costs of a diversion from the Middle Fork in the year 2005, as well as the costs of treatment and transmission of water for domestic use from Shanahan Flat Reservoir. The estimated costs of water treatment facilities are shown in Table 19; estimated costs of pump and pipeline from Shanahan Flat to the area of use is shown in Table 20; and the estimated costs of the future diversion from the Middle Fork is shown in Table 21. These costs are summarized in Table 22.

The costs for water treatment facilities were based upon: (1) initial facilities (precipitator, filter, chemical feed, hypochlorinator) with a capacity of 280 gallons per minute to be constructed in year 1975; second stage construction (additional filter) to a capacity of 560 gpm in year 1985; third stage construction (additional unit plus filter) to a capacity of 1120 gpm in year 2000; and final stage construction (two additional units plus two filters) in year 2015. The present worth of capital and annual costs of present and future water supply treatment is estimated to be $187,700.

The present worth of estimated costs of pump and pipeline from Shanahan Flat into the Service Area ($514,300) was based upon the delivery of all water demand through pipelines by stage development to a point near the center of the Service Area. This method of estimating the cost of serving the Service Area was useful during the process of choosing between alternatives, and is a reasonable means of estimating future costs. The present worth of $156,500 for future diversion facilities from the Middle Fork, in combination with the other costs mentioned above, indicates a total present worth of $858,500 for domestic water supply facilities.

The total present worth of all capital and annual costs estimated for the Shanahan Flat Project is $4,951,000.

Project Benefits

A determination was made of benefits which would result from the domestic water supply, recreation, and fish enhancement purposes of projects proposed in this report.

Stone Meadow Project

The Stone Meadow Project would be justified primarily because of its recreation benefits. Benefits would also result from the cold-water trout fishery. Although domestic water supply benefits result from providing supplemental water to the Service Area from the Middle Fork Diversion after the year 2005, no attempt was made to determine the amount of benefits attributable to this Diversion.

Recreation and Fish Enhancement Benefits. The Department of Parks and Recreation made qualitative studies which contributed toward deriving a unit value for a visitor-day of recreation use. The method used for determining recreation unit values is contained in Appendix A. A value of $2.20 for a visitor-day of use was determined and is used in estimating recreation and fish enhancement benefits at the Stone Meadow Project. The method employed by the Department in estimating future recreation use was explained in Chapter III. Table 23 presents the estimated use of recreation facilities at Stone Meadow Reservoir. The Department of Fish and Game made studies of the cold-water fishery potential and estimated fish production and angler-day use.

The benefits from both the fisheries and other recreation activities are shown in Table 24. The present worth of fish enhancement benefits is estimated to be $520,000, and the present worth of other recreation benefits is estimated to be $12,100,000. The total present worth of these recreation and fisheries benefits is $12,620,000.

Domestic Water Supply Benefits. Since the Stone Meadow Project would not furnish supplemental water supplies to the Service Area prior to year 2005, the present worth (1975) of such benefits would be low. The facilities required to transport water from Middle Fork (released from Stone Meadow) to Shanahan Flat have been treated in this chapter as features of the Shanahan Flat Project. Domestic water supply benefits were considered to accrue to the Shanahan Flat Project.

Shanahan Flat Project

The Shanahan Flat Project, as considered in this report, includes all domestic water supply facilities required to serve the Service Area, including facilities to import supplemental water from the Middle Fork in year 2005. The recreation function of the project, however, would provide the largest project benefit. There would also be an appreciable reservoir fish enhancement benefit.

Recreation and Fish Enhancement Benefits. The recreation benefits were determined from estimates of use as shown in Table 25. The basis for estimates of recreation unit values have been previously presented. The fish enhancement benefits are based on 3,260 angler-days of annual use, which are justified on the basis of natural propagation of the warm-water fish. The estimated total use of recreation facilities, including those used by fishermen, is shown to increase from 54,000 in year 1975 to 233,000 in year 2005. Benefits are based on a continuing annual use of 233,000 after year 2005 because this would be the designed capacity of proposed facilities.

Average annual recreation and fish enhancement benefits based on proposed facilities at Shanahan Flat are shown in Table 26. The unit value for recreation and other recreation uses was estimated to be $1.78. The present worth of recreation benefits is estimated to be $5,512,000, the present worth of fish enhancement benefits is estimated to be $125,000, and the combined total of the two is $5,637,000.

Domestic Water Supply Benefits. It has been previously explained that the value of water provided by the project would be limited by the cost of getting water from another source. Studies under this investigation as well as previous studies made by the Department and by local agencies have concluded that the Hetch Hetch Project of the City of San Francisco would provide the least costly alternative water supply. Estimates have been made of the cost of obtaining water from this source. Table 27 presents the estimated capital and annual costs of water from this source. The pipeline indicated in the table would deliver water to the same central part of the Service Area as the proposed Shanahan Flat Pipeline. The present worth of $1,138,700 for costs of the alternative supply is considered to be the present worth of water supply benefits for the Shanahan Flat Project.

Comparison of Benefits and Costs

The toal development as proposed in this report is justified for further consideration because total benefits are larger than total costs. The present worth of all benefits would be $19,395,700 whereas the present worth of all capital and annual costs would be $13,036,400. This indicates an overall benefit-cost ratio of 1.49 to 1.

Financial Feasibility

Financial feasibility is dependent upon the willingness and ability of the people of an area to finance a project. Studies of financial feasibility of the projects shown in this report were beyond the scope of this investigation. Any project which requires significant local financial participation must be realistically evaluated during the initial portion of future studies to determine that the proposed project is within the financing capability of the sponsoring agency.

TABLE 14

ESTIMATED CAPITAL AND ANNUAL COSTS OF MATHER
DIVERSION AND CONDUIT TO STONE MEADOW
(Based on Prices Prevailing in 1967)

Item	Cost
<u>Capital Costs</u>	
Dam (concrete gravity with overpour section) and Outlet Works (to stream and pipeline)	$ 48,400
Pipeline (to Stone Meadow)	100,900
Total Capital Costs	$149,300
<u>Annual Costs</u>	
Operation and Maintenance	$ 1,200
Replacements and General Expense	1,900
Total Annual Costs	$ 3,100
Present Worth of Annual Costs	$ 66,600
Present Worth of Capital and Annual Costs	$215,900

TABLE 15

ESTIMATED CAPITAL AND ANNUAL COSTS OF
STONE MEADOW DAM AND RESERVOIR
(Based on Prices Prevailing in 1967)

Item	Cost
Capital Costs	
Dam	$1,462,800
Spillway	50,500
Outlet Works	272,300
Clearing, Grubbing and Road Relocation	177,700
Land and Right-of-Way Acquisition	66,700
Total Capital Costs	$2,030,000
Annual Costs	
Operation and Maintenance	$ 3,400
Replacements and General Expense	7,700
Total Annual Costs	$ 11,100
Present Worth of Annual Costs	$ 238,500
Present Worth of Capital and Annual Costs	$2,268,500

TABLE 16

ESTIMATED COSTS OF RECREATION FACILITIES AT
STONE MEADOW RESERVOIR
(Based on Prices Prevailing in 1967)

Year	Capacity, in Visitor-days	Unit[1/] Cost	Cost
Capital Costs			
1975	106,000	$9.15	$992,000[2/]
1985	102,000	9.15	933,000
1995	102,000	9.15	933,000
2005	98,000	9.15	897,000

Present Worth of Capital Costs

	Factor	Present Worth
1975	1.0000	$992,000
1985	0.6756	630,000
1995	0.4564	426,000
2005	0.3083	277,000
	Total Present Worth of Capital Costs	$2,325,000

Annual Costs

Decade	Operation and Maintenance	Replacements
1975-1985	$ 47,100	$ 34,000
1985-1995	77,700	66,600
1995-2005	107,700	99,300
2005-2015	122,400	130,700
2015-2025	122,400	130,700
Present Worth of Annual Costs		
1975-1985	$382,000	$276,000
1985-1995	426,000	365,000
1995-2005	398,000	368,000
2005-2015	306,000	327,000
2015-2025	207,000	221,000
Total	$1,719,000	$1,557,000
Present Worth of Capital and Annual Costs		$5,601,000

1/ Based on day use of 25 percent of overnight use.
2/ Includes $22,000 for land acquisition.

TABLE 17

ESTIMATED CAPITAL AND ANNUAL COST OF
SHANAHAN FLAT DAM AND RESERVOIR
(Based on Prices Prevailing in 1967)

Item	Cost
Capital Costs	
Dam	$ 713,400
Spillway	308,700
Outlet Works	184,200
Clearing, Grubbing and Road Relocation	145,000
Land and Right-of-Way Acquisition	47,400
Total Capital Costs	$1,398,700
Annual Costs	
Operation and Maintenance	$ 1,600
Replacements and General Expense	5,300
Total Annual Costs	$ 6,900
Present Worth of Annual Costs	$ 148,200
Present Worth of Capital and Annual Costs	$1,546,900

TABLE 18

ESTIMATED COSTS OF RECREATION FACILITIES AT
SHANAHAN FLAT RESERVOIR
(Based on Prices Prevailing in 1967)

Year	Capacity, in Visitor-days	Unit[1] Cost	Cost
Capital Costs			
1975	54,000	$6.25	$482,000[2]
1985	58,000	6.25	362,000
1995	58,000	6.25	362,000
2005	63,000	6.25	394,000
Present Worth of Capital Costs			
	Factor		Present Worth
1975	1.0000		$482,000
1985	0.6756		245,000
1995	0.4564		165,000
2005	0.3083		122,000
	Total Present Worth of Capital Costs		$1,014,000
Annual Costs			
Decade	Operation and Maintenance		Replacements
1975-1985	$ 24,900		$ 11,800
1985-1995	42,300		24,500
1995-2005	60,450		37,100
2005-2015	69,900		50,900
2015-2025	69,900		50,900
Present Worth of Annual Costs			
1975-1985	$202,000		$ 95,700
1985-1995	232,000		134,300
1995-2005	224,000		137,300
2005-2015	175,000		127,300
2015-2025	118,000		86,000
	$951,000		$580,600
Present Worth of Capital and Annual Costs			$2,545,600

1/ Based on day use of 110 percent of overnight use.
2/ Includes $145,000 for land acquisition.

TABLE 19

ESTIMATED CAPITAL AND ANNUAL COSTS OF
WATER TREATMENT FACILITIES

Item	Cost
Capital Costs	
Initial (Year 1975) Facilities, (Capacity = 280 GPM) Precipitator, Filter, Chemical Feed, Hypochlorinator, Inlet Control and Storage Tank	$ 51,100
Second Stage (Year 1985) Facilities (Capacity = 560 GPM)	18,000
Third Stage (Year 2000) Facilities (Capacity = 1120 GPM)	69,100
Final Stage (Year 2015) Facilities (Capacity = 2240 GPM)	138,200
Present Worth of Capital Costs	$118,000
Annual Costs	
Initial Stage (1975-1985)	$ 1,900
Second Stage (1985-2000)	2,800
Third Stage (2000-2015)	4,400
Final Stage (2015-2025)	8,800
Present Worth of Annual Cost	$ 69,700
Present Worth of Capital and Annual Costs	$187,700

TABLE 20

ESTIMATED CAPITAL AND ANNUAL COSTS OF
PUMPING AND CONVEYANCE OF WATER FROM
SHANAHAN FLAT RESERVOIR TO PROJECT SERVICE AREA
(Based on Prices Prevailing in 1967)

Item	Cost
Capital Costs	
Capital Cost of Initial Pump Installation	$ 2,600
Present Worth of Future Pump Installations	19,700
Capital Cost of Initial Pipeline	212,100
Present Worth of Future Pipelines	94,400
Present Worth of Capital Costs	$328,800
Annual Costs	
Present Worth of Annual Costs of Power	$107,000
Present Worth of Annual Operation, Maintenance and Replacement Costs and General Expense	78,500
Present Worth of Annual Costs	$185,500
Present Worth of Capital and Annual Costs	$514,300

TABLE 21

ESTIMATED CAPITAL AND ANNUAL COSTS OF FUTURE (YEAR 2005) DIVERSION FROM MIDDLE FORK AT OAKLAND RECREATION CAMP AND CONVEYANCE TO HEADWATER OF BIG CREEK
(Based on Prices Prevailing in 1967)

Item	Cost
Capital Costs	
Dam and Outlet Works	$ 20,700
Pipeline from Diversion to Turbine Penstock	33,100
Turbine Penstock	20,700
Turbine-Pump Unit	45,500
Pump Penstock	20,700
Pipeline from Pump Penstock to Big Creek	215,300
Valves, Fittings, Surge Tank and Miscellaneous	58,000
Total Capital Costs (Year 2005)	$414,000
Annual Costs	
Operation and Maintenance	$ 3,700
Replacements and General Expense	3,200
Total Annual Costs	$ 6,900
Present Worth of Capital Costs	$127,600
Present Worth of Annual Costs	28,900
Total Present Worth of Capital and Annual Costs	$156,500

TABLE 22

SUMMARY OF ESTIMATED INITIAL COSTS AND PRESENT WORTH OF SPECIFIC COSTS FOR DOMESTIC WATER SUPPLY FACILITIES
(Based on Prices Prevailing in 1967)

Item	Initial Cost	Present Worth
Water Treatment Facilities	$ 51,100	$187,700
Pump and Pipeline from Shanahan Flat Reservoir to Service Area	214,700	514,300
Future Diversion of Middle Fork at Oakland Recreation Camp and Conveyance to Big Creek		156,500
Total	$265,800	$858,500

TABLE 23

ESTIMATED USAGE OF RECREATION FACILITIES AT
STONE MEADOW RESERVOIR

Item	Average Annual Usage of Facilities			
	Reservoir	Other Recreation Usage		Total
Year	Fisheries	Overnight	Day	Usage
1975	11,000	79,000	16,000	106,000
1985	11,000	159,000	38,000	208,000
1995	11,000	239,000	60,000	310,000
2005	11,000	314,000	83,000	408,000
2015	11,000	314,000	83,000	408,000
2025	11,000	314,000	83,000	408,000

TABLE 24

ESTIMATED FISH ENHANCEMENT AND RECREATION BENEFITS OF
STONE MEADOW RESERVOIR

Item	Average Annual Benefits					
	Reservoir Fisheries			Other Recreation		
Decade	Annual Usage	Unit Value	Annual Benefit	Annual Usage	Unit Value	Annual Benefit
1975-1985	11,000	$2.20	$24,200	146,000	$2.20	$321,200
1985-1995	11,000	2.20	24,200	248,000	2.20	545,600
1995-2005	11,000	2.20	24,200	348,000	2.20	765,600
2005-2015	11,000	2.20	24,200	397,000	2.20	873,400
2015-2025	11,000	2.20	24,200	397,000	2.20	873,400
Present Worth of Average Annual Benefits						
1975-1985			$196,000			$ 2,610,000
1985-1995			133,000			2,990,000
1995-2005			90,000			2,830,000
2005-2015			61,000			2,190,000
2015-2025			40,000			1,480,000
Total			$520,000			$12,100,000
Total Present Worth of Average Annual Benefits						$12,620,000

TABLE 25

ESTIMATED USAGE OF RECREATION FACILITIES AT
SHANAHAN FLAT RESERVOIR

Item	Average Annual Usage of Facilities			
	Reservoir	Other Recreation		
Year	Fisheries	Overnight	Day	Total
1975	3,260	26,740	24,000	54,000
1985	3,260	51,740	57,000	112,000
1995	3,260	76,740	90,000	170,000
2005	3,260	106,740	123,000	233,000
2015	3,260	106,740	123,000	233,000
2025	3,260	106,740	123,000	233,000

TABLE 26

ESTIMATED FISH ENHANCEMENT AND RECREATION BENEFITS OF
SHANAHAN FLAT RESERVOIR

Item	Average Annual Benefits					
	Reservoir Fisheries			Other Recreation		
Decade	Annual Usage	Unit Value	Annual Benefit	Annual Usage	Unit Value	Annual Benefit
1975-1985	3,260	$1.78	$5,800	79,740	$1.78	$142,000
1985-1995	3,260	1.78	5,800	137,740	1.78	245,000
1995-2005	3,260	1.78	5,800	198,240	1.78	353,000
2005-2015	3,260	1.78	5,800	229,740	1.78	408,000
2015-2025	3,260	1.78	5,800	229,740	1.78	408,000

Present Worth of Average Annual Benefits

1975-1985	$ 47,000	$1,152,000
1985-1995	32,000	1,340,000
1995-2005	21,500	1,310,000
2005-2015	14,500	1,020,000
2015-2025	10,000	690,000
Total	$125,000	$5,512,000

Total Present Worth of Average Annual Benefits $5,637,000

TABLE 27

ESTIMATED CAPITAL AND ANNUAL COSTS OF WATER AND PUMPING FROM HETCH HETCHY AQUEDUCT
(Based on Prices Prevailing in 1967)

Item	Cost
Capital Costs	
Present Worth of Capital Costs of Pumps	$ 108,000
Present Worth of Capital Costs of Pipelines	24,500
Present Worth of Capital Costs	$ 132,500
Annual Costs	
Present Worth of Water Purchases	$ 671,000
Present Worth of Power Purchases	309,200
Present Worth of Annual Operation, Maintenance and Replacement Costs and General Expense	26,000
Present Worth of Annual Costs	$1,006,200
Present Worth of Capital and Annual Costs	$1,138,700

APPENDIX A

GUIDELINES FOR EVALUATING RECREATION BENEFITS

GUIDELINES FOR EVALUATING
RECREATION BENEFITS

GENERAL RECREATION

The objective of the Department of Water Resources in evaluating recreation benefits is to express the net benefit to the recreationist himself of participating in the recreation activity. Once derived, this individual value is multiplied by the total visitation to a project to derive the total benefit of the project.

Two factors obviously have an effect on the benefit to the recreationist; (1) the variety and quality of recreation, and (2) the esthetic qualities of the site. These guidelines consider only those two factors. Other factors such as proximity of the site to population centers and competition with other similar recreation areas are more related to total use than to the benefit accruing to individual recreationists, and, thus, are not considered separately in these guidelines.

Point scores of these factors are established as follows:

Factor	Rating	Point Score
Variety and Quality of Recreation	Poor	1
	Fair	3
	Good	5
Esthetic Qualities of the Site	Poor	1
	Fair	3
	Good	5

The point scores resulting from application of these factors would be added, and the unit value of a day's recreation would be derived from them, within the $0.50 to $2.50 range of values adopted by the Department for general recreation. These point scores cover the $0.50 to $2.50 range in 20 cent increments.

Variety and Quality of Recreation.

Factors to be considered in determining the variety and quality of recreation include analysis of the type of activity, quality of experience, and the quality of development, operation and maintenance of the facilities and area. Activities to be considered include bathing, picnicking, camping, boating, fishing, wildlife use, water skiing, hiking-riding-cycling, and scientific-historic appreciation.

Selection of ratings in this category is guided by the following:

Good Quality - Recreation activities give user varied experiences - National Park Service or Beaches and Parks standards of facility design and operation - Added support facilities to make experience more pleasing (concessions, boat docks, etc.) - Resource produces above normal returns to recreationist.

Fair Quality - Recreation activities supported by facilities necessary to protect health and safety - Below National Park Service or Beaches and Parks standards of facility design and operations. Delineated areas for activities. Resource produces reasonable returns to recreationist.

Poor Quality - Recreation activity not prohibited, but limited by lack of resources or facilities. - Uncontrolled environment.

Esthetic Qualities of the Site.

Factors to be considered in determining the esthetic qualities of the site include: (1) fluctuations in water surface elevation of reservoirs or other project operations and other aquatic factors, (2) geologic-topographic, (3) vegetative cover, (4) climate, and (5) other environmental influences.

Selection of ratings in this category is guided by the following:

Good Quality - A relatively small reduction in the ratio of average surface area to the average annual maximum surface area in the course of a recreation season - An unusually clear and interesting reservoir - Superior vegetative cover - good climate - absence of obnoxious noise, odor, unsightly works - opportunity for seclusion.

Fair Quality - A normal reduction in the ratio of average surface area to the average annual maximum surface area in the course of a recreation season - Geologic, climatic, and vegetative elements of a standard nature; i.e., useful and pleasant, but not outstandingly so - Little opportunity for seclusion - Possible presence of distractions from unrelated activity, e.g., noise, odor, unpleasant works visible, etc.

Poor Quality - A relatively large reduction in the ratio of average surface area to the average annual maximum surface area in the course of a recreation season - Vegetative cover deficient in shade or esthetic character - Geologic and climatic characteristics standard or deficient - Little or no opportunity for seclusion or escape from evidence of distracting activity.

Application of Guidelines.

The factors used in these guidelines are environmental considerations which probably can be best evaluated by qualified recreation planners.

In applying these factors within Departmental programs it is intended that primary consideration will be given to the advice of contract recreation planning personnel of theDepartment of Parks and Recreation.

Further, it is intended that supplementary guidelines or procedures will be devised by recreation planning personnel of the Department of Parks and Recreation. Such supplementary or detailed procedures will be desirable to assure greater uniformity in rating procedures, and will allow numerical ratings intermediate between the rather wide point spreads of these general guidelines.

SPECIALIZED RECREATION

The Department will use the definition of activities contained in Senate Document No. 97, 87th Congress, for specialized recreation. Further, the Department will use the range of values -- $2.00 to $6.00 -- established in that document.

Criteria with ratings and point scores are not yet developed for selecting specific values within the range for specialized recreation. With the exception of trout fishing, the incidence of specialized recreation in the Department's program will be rare, and each situation will be highly individualized, requiring special consideration.

Unit values above the minimum for specialized recreation will require justification which must be approved by the Chief Engineer. As the Department gains experience in evaluating recreation under these procedures, it is expected that the requirement for special justification will be relaxed for certain activities or geographical areas.

Trout Fishing

When a trout fishery is associated with a recreation area offering a variety of activities, such as a reservoir, and no unusual cost or scarcity factors are included, those recreationists participating in trout fishing will be evaluated as general recreation.

When the trout fishing is isolated from a general recreation situation and appears as the dominant recreation activity, such as a stream fishery made possible by flows released for fish enhancement, it may be considered as specialized recreation.

When it is necessary in a reservoir situation to separate fish enhancement from recreation, such as for a Davis-Grunsky project where both purposes are included in the grant application, the activities will be accounted separately, and the same general recreation unit value will be applied to both.

Ocean Salmon Fishing.

Ocean fishing for salmon is not included in these guidelines since this is covered by the agreement with the Department of Fish and Game, setting the value of ocean-caught, sport salmon at $0.34 per pound of salmon.

Evaluating Specialized Recreation.

The bulk of the specialized recreation activities are based on the use of fish and wildlife resources. Because of this, in instances where values higher than the minimum appear justified, and where special justification for higher values will be sought, the advice of personnel from the Department of Fish and Game will be given primary consideration.

Further, it is intended that guidelines or procedures for selecting specific values within the specialized recreation range will be devised jointly by personnel of the Department of Water Resources, and the Department of Fish and Game; with the Department of Parks and Recreation participating, if appropriate.

APPENDIX B

OPERATION STUDIES

EXPLANATION OF STORAGE OPERATION STUDIES

The following explanations of methods used in conducting storage operations studies are presented because of the criteria which were evolved during the investigation. As previously explained, the Department does not infer any interpretation of water rights through presentation of these studies which are designed to be in general accord with previous agreements.

The tabulated quantities presented in Tables 28 through 33 are summarized from operation computations in which each year was broken into two periods, one period from September 1 through May 31 and the other period from June 1 through August 31. May 31 represents the approximate beginning of the recreation season and August 31 represents the approximate end.

STONE MEADOW RESERVOIR (Tables 28, 29, and 30)

An explanation of each of the columns follows:

Column Number	Explanation
(1)	September 1 through August 31 operation year was chosen for convenience in making computations which could show storage of the approximate beginning and ending of the recreation season.
(2)	Storage at approximate beginning of the recreation season on May 31.
(3)	Storage at the end of the operation season. It is computed as follows: To the August 31 storage of the previous year add Column (9) and subtract (10), (11), (11A), and (12).
(4)	Water surface area at approximate beginning of the recreation season.
(5)	Water surface area at approximate ending of the recreation season
(6)	Estimated "dry year" flow at damsite (see section on operation studies in Chapter III for "dry year" definition) if the reservoir were not constructed. This is used to compute streamflow depletions.

Column Number	Explanation
(7)	Estimated natural inflow from the watershed tributary to the reservoir site. This differs from Column (6) by the amount of estimated natural runoff from the reservoir site.
(8)	Estimated inflow to the reservoir from Mather Diversion.
(9)	Total estimated inflow to the reservoir. This is the sum of Columns (7) and (8).
(10)	The difference between the estimated evaporation from and precipitation on the reservoir expressed in acre-feet.
(11)	Releases to the streams below the dam other than those required for domestic water supply, Column (11A) and September streamflow accretions, Column (12).
(11A)	Release for export to Shanahan Flat for domestic water supply. These releases would not be required until after the year 2005. See Column (8) of Shanahan Flat Reservoir operation for explanation of quantities.
(12)	Releases in September of dry years required to make streamflow accretions balance previous 12-month streamflow depletions caused by both Stone Meadow and Shanahan Flat Reservoirs.
(13)	Dry year streamflow depletions caused by Stone Meadow Reservoir. This is computed as follows: From the sum of Columns (6) and (8), subtract Column (11). The sum of Columns (6) and (8) represent the water taken from the stream system to operate the project and Column (11) represents water returned to the stream system.
(14)	Dry years streamflow depletion caused by Shanahan Flat Reservoir. These quantities are taken from the Shanahan Flat operations and are shown in Column 13 of Tables 31, 32 and 33.

SHANAHAN FLAT RESERVOIR (Tables 31, 32, and 33)

An explanation of the columns follows:

(1) September 1 through August 31 operation year was chosen for convenience in making computations which would show storage at the approximate beginning and ending of the recreation season.

Column Number	Explanation
(2)	Storage at the approximate beginning of the recreation season on May 31.
(3)	Storage at the end of the operation year. It is computed as follows: To the August 31 storage of the previous year, add Column (8) and subtract Columns (10), (11) and (12).
(4)	Water surface area at the approximate beginning of the recreation season.
(5)	Water surface area of the approximate ending of the recreation season.
(6)	Estimated "dry year" flow at the damsite if the reservoir were not constructed. This is used to compute streamflow depletions. In the case of Shanahan Flat Reservoir, dry year flows at the damsite are considered to be essentially the same as the inflow from the watershed tributary to the reservoir (Column 7). The estimated 2.4 percent difference in flow is less than the accuracy of streamflow estimates.
(7)	See Column (6).
(8)	Imports of water to the Big Creek basin from releases from Stone Meadow Reservoir and re-diversion from the Middle Fork at Oakland Recreation Camp. These imports would not be required until after the year 2005. The imported quantities were determined as follows: The capacity of the turbine-pump and conveyance facilities would be 2.8 cubic feet per second. With an estimated down time of 10% for the turbine-pump, 150 acre-feet per month could be imported. If the reservoir fills by May 31, imports at the rate of 150 acre-feet per month would be made in June, July, and August and then the turbine-pump would be turned off. If the reservoir were not full by the following March 1, the turbine-pump would be started and would continue to run until the reservoir fills.
(9)	Total inflow to the reservoir. This is the sum of Columns (7) and (8).
(10)	The difference between the estimated evaporation from and precipitation on the reservoir.
(11)	Releases to the stream below the dam.
(12)	Release for domestic use within the project service area.

Column Number	Explanation
(13)	Dry year streamflow depletions caused by Shanahan Flat Reservoir. These depletions are the arithmetic difference between Column (6) and Column (11) and correspond to the depletions shown in Column (14) of Tables 28 through 30. Releases from Stone Meadow Reservoir during September of dry years result in streamflow accretions to balance these depletions.

TABLE 28. ANNUAL OPERATION STUDY OF STONE MEADOW RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 1975
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 31)	Storage		Water Surface Area		Natural:	Inflows			Evaporation Minus Precipitation	Releases			Dry Year Depletions	
	May 31	End of Year (August 31)	May 31	Aug. 31	Dry Year: Flow @ Damsite	Watershed Tributary to Res.	Diversion From MF	Total		Stream Release	Domestic Release	Sept. Accretions	Stone Meadow	Shanahan Flat
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(11A)	(12)	(13)	(14)
		8,250		227										
1926-27	8,500	8,299	231	228		2,735	4,460	7,195	132	7,014				
28	8,500	8,251	231	227	2,186	1,968	3,410	5,378	259	5,167			429	318
29	8,500	8,277	231	227	1,411	1,270	3,310	4,580	339	3,468		747	1,253	435
30	8,500	8,250	231	227	1,449	1,304	4,010	5,314	371	3,282		1,688	2,177	353
1930-31	8,500	8,225	231	227	625	562	3,200	3,762	423	834		2,530	2,991	61
32	8,500	8,352	231	229	3,126	2,814	4,450	7,264	156	3,929		3,052		
33	8,500	8,288	231	228	1,540	1,386	3,700	5,086	367	4,783			457	433
34	8,500	8,227	231	227	765	688	2,960	3,648	367	2,452		890	1,273	407
35	8,500	8,343	231	229		3,282	4,540	7,822	17	6,009		1,680		
1935-36	8,500	8,330	231	229		2,963	4,460	7,423	254	7,182				
37	8,500	8,321	231	228		2,992	4,430	7,422	104	7,327				
38	8,500	8,500	231	231		6,005	4,750	10,755	-173	10,749				
39	8,500	8,240	231	227	1,248	1,123	3,310	4,433	345	4,348			210	285
40	8,500	8,261	231	227		2,666	3,870	6,536	40	5,980		495		
1940-41	8,500	8,419	231	230		3,714	4,490	8,204	42	8,004				
42	8,500	8,447	231	230		3,861	4,460	8,321	57	8,236				
43	8,500	8,315	231	228		3,334	4,460	7,794	93	7,833				
44	8,500	8,316	231	228	2,066	1,859	3,790	5,649	305	5,343			513	353
45	8,500	8,342	231	229		2,890	4,440	7,330	120	6,318		866		
1945-46	8,500	8,306	231	228		2,915	4,430	7,345	230	7,151				
47	8,500	8,247	231	227	1,482	1,343	3,250	4,593	385	4,267			475	390
48	8,500	8,324	231	228		1,906	3,940	5,846	371	4,533		865		
49	8,500	8,263	231	227		1,595	3,920	5,515	415	5,161				
50	8,500	8,272	231	227		2,777	4,380	7,157	362	6,786				
1950-51	8,500	8,279	231	227	2,989	2,691	3,690	6,381	175	6,199			480	233
52	8,500	8,500	231	231		3,602	4,640	8,242	92	7,216		713		
53	8,500	8,343	231	228		1,884	4,410	6,294	380	6,071				
54	8,500	8,297	231	228		2,023	3,690	5,713	319	5,440				
55	8,500	8,276	231	227	1,483	1,335	3,620	4,955	413	4,563			540	400
1955-56	8,500	8,415	231	230		4,622	4,540	9,162	-140	8,223		940		
57	8,500	8,313	231	228		1,932	4,120	6,052	281	5,873				
58	8,500	8,500	231	231		4,188	4,580	8,768	11	8,570				
59	8,500	8,241	231	227	1,193	1,074	3,130	4,204	449	4,014			309	372
60	8,500	8,245	231	227	1,278	1,150	3,290	4,440	305	3,450		681	1,118	363
1960-61	8,500	8,237	231	227	740	666	2,470	3,136	410	1,253		1,481	1,957	156
62	8,500	8,323	231	228		2,202	4,440	6,642	193	4,250		2,113		
63	8,500	8,365	231	228		2,585	4,420	7,005	125	6,838				
64	8,500	8,266	231	227	1,349	1,214	3,290	4,504	330	4,273			366	384
65	8,500	8,440	231	230		3,236	4,450	7,686	70	6,692		750		
66	8,500	8,220	231	227	1,822	1,614	3,380	4,994	388	4,826				

TABLE 29. ANNUAL OPERATION STUDY OF STONE MEADOW RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 2005
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 31) (1)	Storage: May 31 (2)	Storage: End of Year (August 31) (3)	Water Surface Area: May 31 (4)	Water Surface Area: Aug. 31 (5)	Natural: Dry Year: Flow @ Damsite (6)	Inflows: Watershed Tributary to Res. (7)	Inflows: Diversion From MF (8)	Inflows: Total (9)	Evaporation Minus Precipitation (10)	Releases: Stream Release (11)	Releases: Domestic Release (11A)	Releases: Sept. Accretions (12)	Dry Year Depletions: Stone Meadow (13)	Dry Year Depletions: Shanahan Flat (14)
		8,250		227										
1926-27	8,500	8,299	231	228		2,735	4,460	7,195	132	7,014				
28	8,500	8,251	231	227	2,186	1,968	3,410	5,378	259	5,167			429	821
29	8,500	8,277	231	227	1,411	1,270	3,310	4,580	339	2,965		1,250	1,756	435
30	8,500	8,250	231	227	1,447	1,304	4,010	5,314	371	2,779		2,191	2,680	597
1930-31	8,190	8,240	226	227	625	562	3,200	3,762	408	87		3,277	3,738	61
32	8,500	8,352	231	229	3,126	2,814	4,450	7,264	164	3,189		3,799		
33	8,500	8,288	231	228	1,540	1,386	3,700	5,086	367	4,783			457	759
34	8,500	8,227	231	227	765	688	2,960	3,648	367	2,126		1,216	1,599	450
35	8,500	8,343	231	229		3,282	4,540	7,822	17	5,640		2,049		
1935-36	8,500	8,330	231	229		2,963	4,460	7,423	254	7,182				
37	8,500	8,321	231	229		2,992	4,430	7,422	104	7,327				
38	8,500	8,500	231	231		6,005	4,750	10,755	-173	10,749				
39	8,500	8,240	231	227	1,248	1,123	3,310	4,433	345	4,348			210	785
40	8,500	8,261	231	227		2,666	3,870	6,536	40	5,480		995		
1940-41	8,500	8,419	231	230		3,714	4,490	8,204	42	8,004				
42	8,500	8,447	231	230		3,861	4,460	8,321	57	8,236				
43	8,500	8,315	231	228		3,334	4,460	7,794	93	7,833				
44	8,500	8,316	231	228	2,066	1,859	3,790	5,649	305	5,343			513	855
45	8,500	8,342	231	229		2,890	4,440	7,330	120	5,816		1,368		
1945-46	8,500	8,306	231	228		2,915	4,430	7,345	230	7,151				
47	8,500	8,247	231	227	1,482	1,343	3,250	4,593	385	4,267			475	882
48	8,500	8,324	231	228		1,906	3,940	5,846	371	4,041		1,357		
49	8,500	8,263	231	227		1,595	3,920	5,515	415	5,161				
50	8,500	8,272	231	227		2,777	4,380	7,157	362	6,786				
1950-51	8,500	8,279	231	227	2,989	2,691	3,690	6,381	175	6,199			480	741
52	8,500	8,500	231	231		3,602	4,640	8,242	95	6,705		1,221		
53	8,500	8,343	231	228		1,884	4,410	6,294	380	6,071				
54	8,500	8,297	231	228		2,023	3,690	5,713	319	5,440				
55	8,500	8,276	231	227	1,483	1,335	3,620	4,955	413	4,563			540	731
1955-56	8,500	8,415	231	230		4,622	4,540	9,162	-140	7,892		1,271		
57	8,500	8,313	231	228		1,932	4,120	6,052	281	5,873				
58	8,500	8,500	231	231		4,188	4,580	8,768	11	8,570				
59	8,500	8,241	231	227	1,193	1,074	3,130	4,204	449	4,014			309	656
60	8,500	8,245	231	227	1,278	1,150	3,290	4,440	305	3,166		965	1,402	846
1960-61	8,160	8,237	231	227	740	666	2,881	3,547	410	897		2,248	2,724	156
62	8,500	8,323	231	228		2,202	4,440	6,642	193	3,483		2,880		
63	8,500	8,365	231	228		2,585	4,420	7,005	125	6,838				
64	8,500	8,266	231	227	1,349	1,214	3,290	4,504	330	4,273			366	472
65	8,500	8,440	231	230		3,236	4,450	7,686	70	6,604		838		
66	8,500	8,220	231	227		1,614	3,380	4,994	388	4,826				

TABLE 30. ANNUAL OPERATION STUDY OF STONE MEADOW RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 2025
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 31)	Storage		Water Surface Area		Natural	Inflows			Evaporation Minus Precipitation	Releases			Dry Year Depletions	
	May 31	End of Year (August 31)	May 31	Aug. 31	Dry Year: Flow @ Damsite	Watershed Tributary to Res.	Diversion From MF	Total		Stream Release	Domestic Release	Sept. Accre- tions	Stone Meadow	Shanahan Flat
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(11A)	(12)	(13)	(14)
1925-26		8,147		225										
27	8,500	7,999	231	224		2,735	4,460	7,195	133	6,760	450			
28	8,500	7,951	231	223	2,186	1,968	3,410	5,378	258	4,718	450		878	1,612
29	8,500	7,977	231	224	1,411	1,270	3,310	4,580	338	826	900	2,490	3,895	435
30	8,500	7,950	231	223	1,449	1,304	5,169	6,473	370		1,800	4,330	6,618	597
1930-31	2,852	2,389	139	126	625	562	3,200	3,762	308		1,800	7,215	3,825	61
32	8,500	8,052	231	224	3,126	2,814	8,145	10,959	210		1,200	3,886		
33	8,500	7,988	231	224	1,540	1,386	3,700	5,086	365	3,885	900		1,355	759
34	8,500	7,927	231	222	765	688	3,528	4,216	363		1,800	2,114	4,293	450
35	8,500	8,043	231	224		3,282	4,540	7,822	23	1,740	1,200	4,743		
1935-36	8,500	8,030	231	224		2,963	4,460	7,423	71	6,915	450			
37	8,500	8,021	231	224		2,992	4,430	7,422	107	6,874	450			
38	8,500	8,303	231	228		6,005	4,750	10,755	-164	10,187	450			
39	8,500	7,940	231	223	1,248	1,123	3,310	4,433	343	3,553	900		1,262	1,060
40	8,500	7,961	231	223		2,666	3,870	6,536	44	3,699	450	2,322		
1940-41	8,500	8,119	231	225		3,714	4,490	8,204	46	7,550	450			
42	8,500	8,147	231	225		3,861	4,460	8,321	62	7,781	450			
43	8,500	8,015	231	224		3,334	4,460	7,794	97	7,379	450			
44	8,500	8,016	231	224	2,066	1,859	3,790	5,649	305	4,893	450		963	1,195
45	8,500	8,043	231	224		2,890	4,440	7,330	122	4,573	450	2,158		
1945-46	8,500	8,006	231	224		2,915	4,430	7,345	228	6,704	450			
47	8,500	7,947	231	223	1,482	1,343	3,250	4,593	383	3,369	900		1,372	882
48	8,500	8,024	231	224		1,906	3,940	5,846	369	1,346	1,800	2,254		
49	8,500	7,963	231	223		1,595	3,920	5,515	412	3,514	1,650			
50	8,500	7,972	231	224		2,777	4,380	7,157	360	5,888	900			
1950-51	8,500	7,979	231	224	2,989	2,691	3,690	6,381	177	5,747	450		632	1,534
52	8,500	8,299	231	223		3,602	4,640	8,242	94	5,212	450	2,166		
53	8,500	8,043	231	224		1,884	4,410	6,294	376	5,274	900			
54	8,500	7,997	231	224		2,023	3,690	5,713	318	4,541	900			
55	8,500	7,976	231	223	1,483	1,335	3,620	4,955	410	3,666	900		1,437	731
1955-56	8,500	8,115	231	225		4,622	4,540	9,162	-133	5,938	1,050	2,168		
57	8,500	8,014	231	224		1,932	4,120	6,052	282	4,971	900			
58	8,500	8,235	231	227		4,188	4,580	8,768	18	7,329	1,200			
59	8,500	7,941	231	223	1,193	1,074	3,130	4,204	446	3,152	900		1,171	656
60	8,500	7,945	231	223	1,278	1,150	3,290	4,440	305	504	1,800	1,827	4,064	1,003
1960-61	5,199	4,695	181	174	740	666	3,300	3,966	349		1,800	5,067	4,040	156
62	8,500	8,023	231	224		2,202	6,884	9,086	212		1,350	4,196		
63	8,500	8,065	231	224		2,585	4,420	7,005	128	6,385	450			
64	8,500	7,966	231	223	1,349	1,214	3,290	4,504	329	3,374	900		4,555	472
65	8,500	8,140	231	225		3,236	4,450	7,686	74	1,211	1,200	5,027		
66	8,500	7,946	231	223	1,822	1,640	3,380	5,020	386	3,928	900			

TABLE 31. ANNUAL OPERATION STUDY OF SHANAHAN FLAT RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 1975
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 1)	Storage		Water Surface Area		Natural	Inflows			Evaporation Minus Precipitation	Releases		Dry Year Depletions
	May 31	End of Year (August 31)	May 31	August 31	Dry Year Flow @ Damsite	Watershed Tributary to Res.	Import from Stone Meadow	Total		Stream Releases	Domestic Releases	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		3,607		122								
1926-27	3,920	3,622	129	122		3,586		3,586	78	3,343	150	
28	3,920	3,607	129	122	2,122	2,122		2,122	183	1,804	150	318
29	3,920	3,658	129	123	435	435		435	234		150	435
30	3,920	3,602	129	122	597	597		597	259	244	150	353
1930-31	3,511	3,214	120	112	61	61		61	299		150	61
32	3,920	3,628	129	122		5,135		5,135	113	4,458	150	
33	3,920	3,618	129	122	759	759		759	293	326	150	433
34	3,920	3,607	129	122	450	450		450	268	43	150	407
35	3,920	3,705	129	124		4,683		4,683	73	4,362	150	
1935-36	3,920	3,654	129	123		5,529		5,529	70	5,360	150	
37	3,920	3,665	129	123		6,368		6,368	65	6,142	150	
38	3,920	3,741	129	125		12,217		12,217	- 87	12,078	150	
39	3,920	3,613	129	122	1,060	1,060		1,060	263	775	150	285
40	3,920	3,635	129	122		4,723		4,723	59	4,492	150	
1940-41	3,920	3,694	129	124		7,429		7,429	27	7,193	150	
42	3,920	3,699	129	124		4,212		4,212	120	3,937	150	
43	3,920	3,652	129	123		4,737		4,737	70	4,564	150	
44	3,920	3,623	129	122	1,478	1,478		1,478	232	1,125	150	353
45	3,920	3,660	129	123		3,986		3,986	132	3,667	150	
1945-46	3,920	3,623	129	122		1,797		1,797	165	1,519	150	
47	3,920	3,609	129	122	882	882		882	254	492	150	390
48	3,920	3,632	129	122		1,070		1,070	245	652	150	
49	3,920	3,615	129	122		992		992	239	620	150	
50	3,920	3,603	129	122		1,212		1,212	239	835	150	
1950-51	3,920	3,614	129	122	4,652	4,652		4,652	72	4,419	150	233
52	3,920	3,656	129	123		6,868		6,868	- 2	6,678	150	
53	3,920	3,635	129	122		1,300		1,300	202	969	150	
54	3,920	3,622	129	122		1,150		1,150	182	831	150	
55	3,920	3,607	129	122	731	731		731	265	331	150	400
1955-56	3,920	3,639	129	123		7,416		7,416		7,234	150	
57	3,920	3,626	129	122		824		824	227	460	150	
58	3,920	3,666	129	123		6,431		6,431	12	6,229	150	
59	3,920	3,600	129	122	656	656		656	288	284	150	372
60	3,920	3,603	129	122	1,003	1,003		1,003	210	640	150	363
1960-61	3,614	3,314	122	115	156	156		156	295		150	156
62	3,920	3,607	129	122		3,127		3,127	166	2,518	150	
63	3,920	3,646	129	123		3,437		3,437	106	3,142	150	
64	3,920	3,614	129	122	472	472		472	266	88	150	384
65	3,920	3,657	129	123		4,569		4,569	29	4,347	150	
66	3,920	3,602	129	122	1,403	1,403		1,403	263	1,045	150	

TABLE 32. ANNUAL OPERATION STUDY OF SHANAHAN FLAT RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 2005
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 1)	Storage		Water Surface Area		Natural Dry Year Flow @ Damsite	Inflows			Evaporation Minus Precipitation	Releases		Dry Year Depletions
	May 31	End of Year (August 31)	May 31	Aug. 31		Watershed Tributary to Res.	Import from: Stone Meadow	Total		Stream Releases	Domestic Releases	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		3,499		119								
1926-27	3,920	3,416	129	117		3,586		3,586	82	2,937	650	
28	3,920	3,401	129	117	2,122	2,122		2,122	186	1,301	650	821
29	3,422	2,973	117	106	435	435		435	213		650	435
30	3,186	2,697	111	98	597	597		597	223		650	597
1930-31	2,325	1,890	85	72	61	61		61	218		650	61
32	3,920	3,422	129	117		5,135		5,135	165	2,788	650	
33	3,748	3,248	125	113	759	759		759	283		650	759
34	3,300	2,810	114	101	450	450		450	238		650	450
35	3,920	3,499	129	119		4,683		4,683	105	3,239	650	
1935-36	3,920	3,448	129	118		5,529		5,529	77	4,853	650	
37	3,920	3,459	129	118		6,368		6,368	73	5,634	650	
38	3,920	3,535	129	120		12,217		12,217	- 73	11,564	650	
39	3,920	3,407	129	117	1,060	1,060		1,060	263	275	650	785
40	3,920	3,429	129	117		4,723		4,723	67	3,984	650	
1940-41	3,920	3,488	129	119		7,429		7,429	37	6,683	650	
42	3,920	3,493	129	119		4,212		4,212	126	3,431	650	
43	3,920	3,446	129	117		4,737		4,737	77	4,057	650	
44	3,920	3,417	129	117	1,478	1,478		1,478	234	623	650	855
45	3,920	3,454	129	118		3,986		3,786	136	3,163	650	
1945-46	3,920	3,417	129	117		1,797		1,797	168	1,016	650	
47	3,912	3,397	128	117	882	882		882	252		650	882
48	3,920	3,426	129	118		1,070		1,070	244	147	650	
49	3,920	3,409	129	117		992		992	240	119	650	
50	3,920	3,397	129	117		1,212		1,212	239	335	650	
1950-51	3,920	3,408	129	117	4,652	4,652		4,652	80	3,911	650	741
52	3,920	3,451	129	118		6,868		6,868	8	6,167	650	
53	3,920	3,479	129	118		1,300		1,300	203	469	650	
54	3,920	3,416	129	117		1,150		1,150	184	329	650	
55	3,751	3,240	125	113	731	731		731	257		650	731
1955-56	3,920	3,433	129	118		7,416		7,416	19	6,554	650	
57	3,879	3,381	128	116		824		824	226		650	
58	3,920	3,460	129	118		6,431		6,431	23	5,679	650	
59	3,706	3,413	124	117	656	656		656	53		650	656
60	3,920	3,397	129	117	1,003	1,003		1,003	212	157	650	846
1960-61	3,116	2,635	109	96	156	156		156	268		650	156
62	3,920	3,401	129	117		3,127		3,127	181	1,530	650	
63	3,920	3,440	129	118		3,437		3,437	111	2,637	650	
64	3,507	3,010	120	107	472	472		472	252		650	472
65	3,920	3,451	129	118		4,569		4,569	56	3,422	650	
66	3,920	3,396	129	117	1,403	1,403		1,403	263	545	650	

TABLE 33. ANNUAL OPERATION STUDY OF SHANAHAN FLAT RESERVOIR
UNDER DEMANDS ESTIMATED FOR YEAR 2025
(Water quantities in acre-feet and surface areas in acres)

Year (September 1 through August 1)	Storage		Water Surface Area		Natural Dry Year Flow @ Damsite	Inflows			Evaporation Minus Precipitation	Releases		Dry Year Depletions
	May 31	End of Year (August 31)	May 31	Aug. 31		Watershed Tributary To Res.	Import from: Stone Meadow	Total		Stream Releases	Domestic Releases	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
		3,401		117								
1926-27	3,920	3,388	129	116		3,586	450	4,036	86	2,073	1,890	
28	3,920	3,373	129	116	2,112	2,122	450	2,572	187	510	1,890	1,612
29	3,082	2,618	109	95	435	435	900	1,335	200		1,890	435
30	3,419	2,890	117	103	597	597	1,800	2,397	235		1,890	597
1930-31	3,103	2,594	109	94	61	61	1,800	1,861	267		1,890	61
32	3,920	3,394	129	117		5,135	1,200	6,335	136	3,509	1,890	
33	3,408	2,895	117	104	759	759	900	1,659	268		1,890	759
34	3,536	3,006	120	107	450	450	1,800	2,250	249		1,890	450
35	3,920	3,471	129	119		4,683	1,200	5,883	95	3,433	1,890	
1935-36	3,920	3,420	129	117		5,529	450	5,979	77	4,063	1,890	
37	3,920	3,431	129	118		6,368	450	6,818	75	4,842	1,890	
38	3,920	3,507	129	120		12,217	450	12,667	- 73	10,774	1,890	
39	3,855	3,318	127	115	1,060	1,060	900	1,960	259		1,890	1,060
40	3,920	3,401	129	117		4,723	450	5,173	70	3,130	1,890	
1940-41	3,920	3,460	129	119		7,429	450	7,879	37	5,893	1,890	
42	3,920	3,465	129	119		4,212	450	4,662	126	2,641	1,890	
43	3,920	3,418	129	117		4,737	450	5,187	78	3,266	1,890	
44	3,920	3,389	129	117	1,478	1,478	900	2,378	234	283	1,890	1,195
45	3,920	3,426	129	117		3,986	450	4,436	137	2,372	1,890	
1945-46	3,920	3,389	129	117		1,797	450	2,247	169	225	1,890	
47	3,572	3,043	121	107	882	882	900	1,782	238		1,890	882
48	3,920	3,398	129	117		1,070	1,800	2,870	245	380	1,890	
49	3,700	3,171	124	111		992	900	1,892	229		1,890	
50	3,920	3,369	129	116		1,212	1,500	2,712	240	384	1,890	
1950-51	3,920	3,378	129	116	4,652	4,652	450	5,102	85	3,118	1,890	1,534
52	3,920	3,423	129	117		6,868	450	7,318	10	5,373	1,890	
53	3,920	3,401	129	117		1,300	900	2,200	204	128	1,890	
54	3,909	3,379	128	117		1,150	900	2,050	182		1,890	
55	3,402	2,879	117	103	731	731	900	1,631	241		1,890	731
1955-56	3,920	3,405	129	117		7,416	1,500	8,916	40	6,460	1,890	
57	3,539	3,029	120	107		824	900	1,724	210		1,890	
58	3,920	3,432	129	117		6,431	1,800	8,231	41	5,897	1,890	
59	3,366	2,838	116	102	656	656	900	1,556	260		1,890	656
60	3,920	3,369	129	116	1,003	1,003	1,800	2,803	218	164	1,890	1,003
1960-61	2,777	2,286	100	85	156	156	900	1,056	249		1,890	156
62	3,920	3,373	129	116		3,127	1,650	4,777	189	1,611	1,890	
63	3,920	3,413	129	117		3,437	450	3,887	112	1,845	1,890	
64	3,204	2,697	112	98	472	472	900	1,372	194		1,890	472
65	3,920	3,423	129	117		4,569	1,650	6,219	72	3,531	1,890	
66	3,920	3,368	129	117	1,403	1,403	900	2,303	263	205	1,890	